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SUMMARY OF OVERSIGHT HEARINGS ON IMPLEMENTATION OF THE ACID PRECIPITATION ACT OF 1980

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UNITED STATES SENATE

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Prepared at the Request of the
Committee on Energy and Natural Resources
U. S. Senate

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PART ONE: EXECUTIVE SUMMARY

On April 30, 1984 the Senate Committee on Energy and Natural Resources held oversight hearings on the Implementation of the Acid Precipitation Act of 1980. Twenty-five witnesses testified, including four Senators and four representatives of the Administration. Dozens of supporting documents were also introduced into the record.

In response to a request of the Committee, the Congressional Research Service has prepared this summary, which consists of three parts: an abstract; a review of the hearings by issue; and a compilation of excerpted recommendations.

ABSTRACT

1. Most witnesses agreed that acid precipitation is a real problem; but they offered a wide range of views on its causes, on the seriousness of its effects, on its susceptibility to control, and on the potential consequences of any control program.

2. The preponderance of testimony at the hearing supported accelerated research before legislating controls to mitigate acid precipitation, although some witnesses did advocate immediate enactment of control legislation. Thus most witnesses supported the Administration's general approach of limiting the current acid precipitation program to increased funding for the National Acid Precipitation Assessment Program (NAPAP). Many of these witnesses also supported liming lakes to mitigate acidity.

3. Those witnesses who did support immediate enactment of a control program had varied views on how the program should be constituted. Senator George Mitchell, a proponent of starting a control program, urged agreement that a "serious problem which warrants a response" exists, so the debate could focus on "how best to accomplish the goal of minimizing acid precipitation."

4. Several witnesses voiced support for bills to accelerate research, development, and demonstration of new technologies for clean use of fuels. They contended that these new technologies could offer a way of reducing acid precipitation precursors without substantial disruption of traditional fuel use patterns.

5. Much testimony was devoted to the present status of information on the causes and effects of acid rain. (a) The Federal center for this research is the National Acid Precipitation Assessment Program, established under the Acid Precipitation Act of 1980. Its activities were summarized by Dr. Christopher Bernabo, Executive Director of the Interagency Task Force on Acid Precipitation, and are reviewed in NAPAP's 1983 annual report, issued after the hearing and made part of the record. (b) Privately funded research was also reviewed, for example the program of the Electric Power Research Institute. (c) The source/receptor relationship of acid rain pollutants was identified as a critical uncertainty. Witnesses generally agreed that there is a near-linear relationship between emissions and deposition when spatial and temporal scales are large enough (e.g., over the eastern U.S. for one year), but that the relationship is typically non-linear for specific, short-term episodes. (d) Scientists, representing diverse disciplines, testified on research programs that ranged from modeling the transport and transformation of pollutants to their effects on water, soils, and forests.

They generally indicated that the knowledge base is rapidly expanding; but their interpretations of the adequacy of the knowledge base ranged from Dr. Jerald Schnoor, Director of Environmental Engineering, University of Iowa, who concluded, "there are many good reasons to reduce SOx emissions," to others who concluded that further research is necessary and that delays will not risk serious environmental harm.

6. Much testimony was also devoted to the potential impacts of acid precipitation control programs on the nation's economy. (a) Such witnesses observed that control programs could adversely affect utilities, industries, and economic growth--and ultimately consumers--through increased electrical rates, reduced generating reliability, and emissions caps. (b) Such witnesses also observed that control programs had the potential for significantly modifying traditional patterns of fuel use, particularly with respect to high sulfur coal, with concomitant impacts on production and on employment. (c) Such witnesses further noted that the early initiation of control programs could interfere with the demonstration and adoption of new, cleaner, energy technologies now under development by locking utilities into the current generation of technologies. (d) Illustrating the uncertainty of cost projections, Secretary of the Department of Energy Donald P. Hodel presented data indicating that estimates of the costs of control programs vary widely, especially for proposals to reduce sulfur dioxide emissions more than eight million tons.

7. Witnesses varied in the degree of certainty with which they projected the magnitude and range of the effects and impacts they discussed. Some felt reasonably sure controls on emissions would mitigate problems associated with acid precipitation and that the costs would be tolerable, and therefore advocated

enactment of control legislation. But the majority of the witnesses felt that the benefits that might accrue from reducing emisions were much less certain than the costs and potentially adverse consequence of controls, so the majority of witnesses advocated further research before taking action on controls. As stated by Dr. Bernabo, "The understanding of mechanisms in the acid rain issue is vital to avoid spending large amounts of money, dislocating industry and workers, etc. without a reasonably firm foundation that the action will produce the desired benefits."

8. Many witnesses who opposed enacting control legislation before further research results were available nevertheless commented on certain principles that they felt any such legislation should contain. Among the principles mentioned were (a) that the polluter should pay--as opposed to cost-sharing; (b) that a balance between costs and benefits should be sought --by allowing sources to choose how to achieve any required emission reductions rather than by mandating technology; (c) that emissions should not be capped; and (d) that the use of coal should not be discouraged.

9. Research needs were noted by many witnesses, some of whom made general recommendations while others outlined detailed research proposals. The cited research needs fell into several categories, including: (a) research on the transport and transformation of precursor pollutants, sulfur dioxide and nitrogen oxides; (b) research on the effects of acid precipitation; (c) research on ecological phenomena that might be affected by acid precipitation, especially forest decline; (d) research on precipitation, lake, stream, and soil chemistry; (e) monitoring; and (f) research, development, and demonstration of new technologies for controling emissions.

10. The question of forest decline was frequently pointed to as a critical research issue. The witnesses generally agreed on the seriousness of the problem, on the need for further research, and on the present uncertainty of the cause(s). Some witnesses implied that if acid precipitation is shown to be a significant cause of forest decline, then controlling acid rain might well become necessary. Environmental Protection Agency Administrator William Ruckelshaus was the most explicit:

> If the information we were picking up on the forests should show us, through some breakthrough ... that the problem really is forest decline, that seems to be what's causing the problem in the forests, and there were some general scientific agreement on that, then that might lead us to suggest a reduction in sulfur oxide or a sulfur oxide control strategy.

11. On the question of how soon further research would generate sufficient information for decisions on controls to be made, witnesses made three observations: first, that the adequacy of information to make a policy decision is a policy matter, not a scientific one; second, that research might soon clarify how urgent the problem is; and third, that more research on, and scientific understanding of, acid precipitation would inevitably make for better decisions. Further, several witnesses indicated that emissions and deposition appear to have leveled off, suggesting that problems may have stabilized. Dr. Bernabo noted that the National Acid Precipitation Assessment Program has scheduled for 1985 a major assessment of the magnitude of current damges and a summary of the uncertainties surrounding the source/receptor relationship, with more comprehensive, integrated assessments scheduled for 1987 and 1989.

LIST OF WITNESSES, STATEMENTS, AND SUBMITTED MATERIALS
(Roughly categorized for convenience--not in order of appearance)
Witnesses testifying in person marked with an asterisk (*)

A. Members of the Senate
*1. James A. McClure of Idaho
*2. Robert C. Byrd of West Virginia
*3. Wendell Ford of Kentucky
*4. George J. Mitchell of Maine
5. Dan Quayle of Indiana
*6. John Warner of Virginia

B. Representatives of the Administration
*1. A. Alan Hill, Council on Environmental Quality
*2. Donald Paul Hodel, Secretary of the Department of Energy
*3. William D. Ruckelshaus, Administrator of the Environmental Protection Agency

C. Representatives of Scientific Organizations
*1. Dr. Christopher Bernabo, Executive Director, Interagency Task Force on Acid Precipitation
a. Testimony, statement, and answers to written questions
b. National Acid Precipitation Assessment Program Annual Report, 1983
*2. Dr. Bernard Manowitz, National Laboratory Consortium; Brookhaven National Laboratory — testimony, statement and answers to questions
*3. Dr. Raphael Kasper, National Research Council, testimony, statement and answers to questions
4. William Brown, Hudson Institute — statement and Letter to Gov. Cuomo
5. Edward Krug, Connecticut Agricultural Experiment Station — statement plus Science article "Acid Rain on Acid Soil - A New Perspective" and "Report on Sources and Effects in Connecticut"
6. U.S. Geological Survey
a. "An Evaluation of the Trends in Acidity of Precipitation and Related Acidification of Surface Water in North America"
b. "Temporal Trends in the Acidity of Precipitation and Surface Waters of New York"
7. U.S. Environmental Protection Agency, "National Air Pollutant Emission Estimates"

D. Individual Experts
*1. Dr. Jerald T. Schnoor, Civil and Environmental Engineering Program, Univeristy of Iowa, testimony and statement
*2. Dr. Dale Johnson, Environmental Science Division, Oak Ridge National Laboratory, statement and testimony
*3. Dr. Harry G. Enoch, Division of Technology, Kentucky Energy Cabinet, testimony and statement
*4. Dr. Ralph M. Perhac, Deputy Director, Energy and Environmental Division, Electric Power Research Institute
5. Dr. Ian Bruck, "Observations of Montana Boreal Tree Decline and Dieback"
6. Dr. Ellis B. Cowling, School of Forest Resources, North Carolina State University — statement and following articles: "Four Questionable Assumptions Underlying the Clean Air Act of 1970"; "Discovering the Causes, Consequences and Implications of Acid Rain..."; and, "Testimony on Regional Changes in the Growth and Behavior of Forests..."

7. Dr. George E. Hidy, Senior Scientist of Environmental Research and Technology Inc., statement
8. Dr. Arthur Johnson, Associate Professor of Soils, University of Pennsylvania, statement
9. Drs. Richard M. Klein and Hubert Vogelmann, Botany Department, University of Vermont, "Current Status of Research in Acid Rain"

E. Affected Industries
*1. John C. Bard, President, Aluminum Association Inc., testimony and statement
*2. Edward L. Addison, President and Chief Exec. Officer, The Southern Co., for Edison Electric Institute —testimony, statement and research.
*3. Michael Bergman, Staff Scientist, American Public Power Association — testimony and statement plus APPA research report
*4. Carl Bagge, President, National Coal Association — testimony and statement plus "The Acid Rain Fraud - A Criminal Indictment and a Demand for a New Trial"
*5. James C. Wilson, President, Rocky Mountain Energy Co., for Alliance for Clean Energy, testimony and statement
6. American Gas Association, statement
7. Kaiser Aluminum and Chemical, statement
8. American Paper Institute
a. statement
b. NCASI Reports
9. American Iron and Steel Institute, Earl F. Young, Jr., statement
10. Tennessee Valley Authority, statement from the Board of Directors

F. Labor and Other Affected Interests
*1. John Jarvis, United Mine Workers of America, testimony and statement
*2. John N. Dalton, McGuire, Woods & Battle, for United Coal Company, testimony and statement
*3. John Quarles, Chairman, National Environmental Development Association, testimony and statement
*4. Edward F. Haase, Phelps Dodge Corp., for Western Regional Council, testimony and statement
*5. Thomas Altmeyer, Vice President, Mining and Reclamation Council, testimony and statement
6. Electricity Consumers Resource Council, statement
7. Council of Industrial Boiler Owners, statement and attachments
8. Clean Coal Coalition, Leon Green Jr., statement and attachments

G. Other
1. Temple, Barker and Sloane Inc., statement
2. Benesch, Friedlander, Coplan & Aronoff, statement
3. Hunton & Williams, George Freeman, "U.S. Politics of Acid Rain" and "Economic and Energy Policy Implications of Pending Acid Rain Legislative Proposals"
4. Dr. Larry B. Parker, Congressional Research Service, "Mitigating Acid Rain: Implications for High-Sulfur Coal Regions"
5. Dr. Larry B. Parker and Duane A. Thompson, Congressional Research Service, "Acid Rain Legislation and the Future of the Eastern Low-Sulfur Coal Industry"

6. National Wildlife Federation, "Acid Rain: Its State by State Impact"
7. Colorado River Wildlife Council, letter
8. Letter to the President, signed by 24 Senators and Congressmen, dated November 17, 1983
9. Bolye, article in Sports Illustrated, "A Rain of Death on the Striper?"
10. The Courier Journal, "Region Falls Victim to Own Pollution"
11. New York Times, "Seaboard of Stunted Trees"
12. EPA Environmental News, March 15, 1984
13. "Relationship Between the Calvert Committee (NAS) Report and the National Laboratories Critique"

SUMMARY OF OVERSIGHT HEARINGS ON IMPLEMENTATION OF THE ACID PRECIPITATION ACT OF 1980

PURPOSE OF HEARING

On April 30, 1984 the Senate Committee on Energy and Natural Resources held an oversight hearing on the implementation of the Acid Precipitation Act of 1980. In effect, this hearing was a continuation of the Committee's 1982 hearing "Acid Precipitation and the Use of Fossil Fuels."

In opening the hearing, Chairman James A. McClure reviewed the Committee's historical interest in energy and environmental issues. He noted that the Acid Precipitation Act of 1980 recognized the potentially serious problem of acid depostion by establishing a comprehensive 10-year Federal research program, administered by the Interagency Task Force on Acid Precipitation.

Noting the contributions of current research, Chairman McClure observed that "Because of the limited data currently available, there is a reasonable basis for legitimate differences in interpretation among recognized experts." And he commented that the "Task Force effort is directed at developing, as expeditiously as possible, the information needed by policy makers to formulate appropriate actions to deal with acid precipitation.

The hearing itself focused on the "advances that have been made in the state of our scientific knowledge" in three areas: "first, the causes and effects of acid precipitation; second, the adequacy of current knowledge in advancing solutions to the problem; and third, the energy and environmental implications of legislating now in advance of further implementation of the Interagency Task Force Plan."

SCIENTIFIC KNOWLEDGE

Nature of Acidic Rainfall

Acids and acid forming substances may be deposited on the earth in either wet forms such as rain (the most publicized form), or in dry forms. These substances may be either natural in origin or the result of man's activities. Normal rainfall is naturally acidic due to the reaction of atmospheric moisture and carbon dioxide. The conventional wisdom regarding normal rainfall is that it has an acidity of about 5.6 on the pH scale. (On the pH scale of 0 to 14, pure water has a pH of 7.0. The lower the number, the more acid a substance; for example, lemon juice and vinegar have pHs of between 2 and 3. Since the pH scale is logarithmic, a pH of 6 is 10 times more acid than pure water, a pH of 5 is 100 times more acidic, a pH of 4 is 1000 times more acidic and so on.) However, research conducted on remote regions of the world have suggested that the natural acidity of rainfall may be closer to 5.0 than 5.6. As stated by EPA in response to questions from the Committee:

> Annual average (precipitation weighted) pH values as low as 5.1 were reported in some remote areas of the world in 1982. These measurements demonstrate that a pH of 5.6, often considered normal for rainfall in the absence of pollution, cannot be considered a benchmark for comparison purposes. Organic acids are believed responsible for depressing the normal pH to a value closer to 5.0 than the expected 5.6. The origins of these organic acids are presumed to be primarily from natural sources.

Yet, as noted by Senator Mitchell in quoting EPA Administrator Ruckelshaus, the acidity of rainfall in the Northeast is significantly lower than 5.0:

> The northeastern United States and southeastern Canada receive rainfall that is, on average, more acidic than rainfall elsewhere in the country. Rainfall in much of the Northeast has a pH of 4.2 compared with rainfall with a pH of approximately 5.0 to 5.6 elsewhere.

This acid rainfall in the Northeast, according to both Dr. Bernabo of the Interagency Task Force on Acid Precipitation and Administrator Ruckelshaus, is primarily the result of man-made emissions. As stated by Dr. Bernabo in testimony:

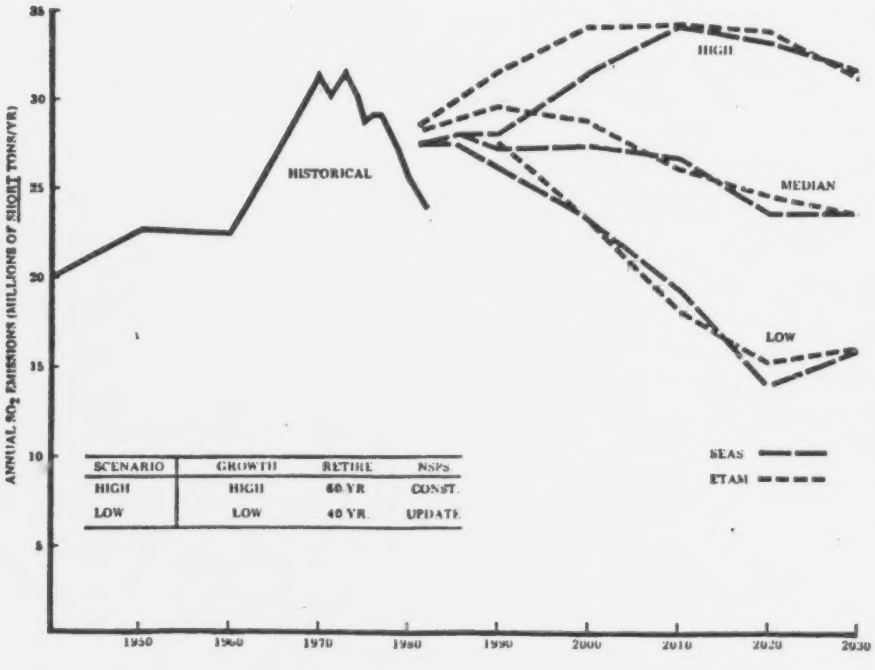
> Now, clearly there is a scientific consensus that man-made emissions have increased the acidity of precipitation in eastern North America, and that, in fact, 90 percent-plus of the acidity in that region is from man-made sources.

While there was consensus on the importance of man's contribution to acid rainfall, there was little regarding the trends of rainfall acidity, either past or future. To the extent SO2 emissions are related to total rainfall acidity, there was no consensus on future emissions of SO2. This uncertainty was illustrated by the testimony of DOE Secretary Hodel:

> Future trends in SO2 emissions are uncertain due to questions about such factors as economic growth, utility boiler life expectancy and New Source Performance Standards stringency. The medians of the range of projections indicate approximately constant emissions in the near term and declining emissions in the long term as existing plants retire and are replaced with new plants meeting stringent emissions limits. Several projections of future trends are shown in Figure 1.

In summarizing the general situation regarding precipitation and trend data, Dr. Bernabo stated the following:

FIGURE 1: National SO2 Emission Projections



Source: Department of Energy

> There is a scientific consensus that man-made emissions have increased the acidity of precipitation over eastern North America, but also that existing data and studies do not constitute an adequate basis for determining the details of past patterns in precipitation acidity. Problems with earlier determination of pH and other factors have called into question all previous attempts to define specific rates and patterns of increased precipitation acidity in eastern North America. Monitoring and research efforts are now underway that will allow improved interpretation of historical data and confident assessment of trends in the future.

It is important to note that rainfall acidity, or "wet deposition" is only part of total acid deposition, although the most well-known. Perhaps an even greater portion of total acid deposition in some cases falls in dry forms, particularly near emission sources. However, as stated by Dr. Bernabo in response to written questions from the Committee, no standardized scientific techniques currently exist to measure dry deposition on a routine basis:

> The relative ratio of wet to dry deposition is unknown. Dry depositon may account for 25% to 80% or more of the acidity deposited in some areas. The timing, amount, and composition of this wet and dry deposition can influence the effects on the sensitive receptors. While a national wet deposition network is operational, no standardized scientific techniques yet exist to measure dry deposition on a routine basis. Near the emission sources, dry deposition is believed to be an important contributor, possibly a predominant contributor, of acid-forming substances due in part to rapid settling of heavier particles. The ratio of wet to dry deposition is also very dependent on weather. If there is a period of low or no precipitation over a broad area, clearly the dry deposition would have to be greater than wet, which might be zero due to the lack of moisture. The National Program has accelerated its research effort on wet and dry acid deposition.

Atmospheric Processes

To understand the relationship between emissions and deposition, considerable research is underway to better understand atmospheric processes which affect that transformation. Discussion during the hearing centered on three aspects of those processes: (1) linearity between emissions and deposition, (2) the relationship between specific sources of emissions and areas of deposition, and (3) the importance of long-range transport of pollutants to deposition. Witness testimony on these aspects of atmospheric processes are discussed below.

Linearity

The concept of linearity refers to the relationship between emissions of acid precursors and subsequent deposition. The problem concerns whether emissions and deposition occur in a one-to-one relationship (linear) or whether the relationship is skewed (non-linear). The issue is critical for considering controls, since a linear relationship means reducing emissions reduces deposition proportionately, while a non-linear relationship could mean that reducing emissions might have proportionately less effect on deposition.

One of the more recent reports on atmospheric processes was issued last summer by the National Academy of Science (NAS). At the hearings, Dr. Rahael G. Kasper of NAS gave the following summary of that report's finding on linearity:

> Contrary to an earlier hypothesis, there is no evidence of a strong nonlinearity in the relationship between aggregate emissions of sulfur oxides and aggregate deposition of sulfuric acid in precipitation in eastern North America. This means that a reduction in the total emissions over a large area in the eastern part of the

> continent is likely to lead to an approximately proportionate reduction in the spatially-integrated, annual average deposition in this area. By "proportionate" we mean that a 20% reduction in emissions would lead to a 20% reduction in deposition, a 40% reduction in emissions to a 40% reduction in deposition, and so forth.

This conclusion was reinforced by the testimony of Dr. Bernabo:

> The precise relationships between emissions and deposition are still unknown, with existing atmospheric models having uncertainties in their predicitions of up to 10 fold. However, based on the limited information available, it has been suggested that when averaged over the entire eastern half of North America for a year or more, there appears to be a nearly one-to-one (linear) relationship between emissions and deposition. Over smaller time and space scales though, this relationship may not be a one-to-one relationship.

As noted above, in stating the relationship between emissions and deposition, both NAS and NAPP placed important conditions on their conclusions. As noted by Dr. Manowitz of the Brookhaven National Laboratories (BNL): "Both the national laboratory critique and the NAS report agree that in general the detailed processes involved in acid deposition are inherently non-linear." Rather, as emphasized by EPA's response to committee questions, the hypothesis of linearity is based on a large spatial area (such as eastern North America) and long averaging times (ca. 1 year). However, for short term espisodes, the process may involve significant non-linearity. As stated by Dr. Manowitz:

> The NAS report points out that short-term (episodes) are very complex and may indeed involve non-linearities. Non-linearities clearly arise, for example, in short-term meteorology and may be important for chemical processes taking place in clouds in winter. When the individual episodes are summed or averaged over the year, however, the non-linearities appear to balance out, or in the case of cloud processes in winter, apparently do not contribute much to annual totals.

Hence, as noted by Dr. Bernabo in response to written questions from the Committee, the case for linearity is not proven (except globally over several years).

The significance of this debate over linearity was summarized by NAPAP in response to questions submitted by the Committee:

> The significance of the linearity debate is that we are still unable to reliably predict deposition at specific sites or over sensitive regions of critical concern. This complicates designing optimized control strategies or providing strong assurances that a given reduction in emissions will result in a specified environmental benefit.

Source-Receptor Relationships

Dr. Bernabo's statement earlier suggests that significant uncertainty still exist regarding specific source-receptor relationships regarding acid deposition. As stated by Dr. Kasper:

> Given currently available computer models, we cannot confidently determine with reasonable accuracy the detailed relationship between emissions from a specific source or highly localized source region and acid deposition in a specific receptor area hundreds of miles away. Thus, while we know the general relationship between average aggregate emissions and deposition, we cannot predict the extent to which acid deposition would be reduced at a given site as a result of restricted emissions from a particular source.

This uncertainty was of specific concern to some members of the Committee. Because most the allocation schemes proposed for acid rain programs are based on utility emissions, the Midwest would have to make the bulk of the reductions. Asked directly whether the NAS report meant that a 50 percent reduction in the Midwest would result in a 50 percent reduction in the northeast, the NAS responded:

> No....A 50 percent reduction of emissions in the Midwest will not guarantee a 50 percent reduction in deposition in the Northeast because other regions of the U.S. and Canada, including the Northeast, also contribute to deposition in the Northeast. The conclusion of the report pertains to emissions of sulfur dioxide and deposition of sulfuric acid, which accounts for about two-thirds of the total acidity in precipitation.

A similar response was given by Dr. Manowitz of BNL to targeting the Midwest for reductions to reduce deposition in the Northeast:

> One will never achieve a reduction in deposition in New England equivalent to a reduction in emissions in the Midwest. The reduction in deposition would be distributed over a variety of locations. In my judgment, present scientific knowledge does not allow a precise statement of how much deposition would be reduced in particular regions for a particular hypothetical decrease in emissions in a given region.

Dr. Bernabo summarized the current state of knowledge regarding source-receptor relationships as follows:

> ...the most straightforward answer about the present state of source/receptor relationships: There are now models (for at least sulfur compounds) which can make predictions of changes in deposition from reduction in emissions, but it is not known whether those predictions are correct.

Long-Range Transport

Because of the uncertainty regarding source-receptor relationships, there was also uncertainty regarding the role of long-range transport of SO2 and NOx. Some witnesses suggested that the closer a sources is to a receptor site, the greater its effect should be on that site. As stated by Dr. Kasper:

> The report concluded that both observational and theoretical evidence exists for long-range transport of pollutants leading to acid deposition. Also, it is appartent that any receptor site will be influenced by both local and distant sources. A specific facility is likely to have a greater effect on a specific receptor site the closer the emitter is to that site. Sources, however, are not uniformly distributed in space. The report also concluded that currently available models of transport and transformation processes are not sufficiently accurate to determine the relative importance for deposition at specific sites of long-range transport as compared with the more direct influences of local sources. Nor are currently available data sufficient for this this purpose.

Dr. Bernabo summarized the uncertainty regarding the relative importance of local versus distant pollution sources as follows:

> Most of the acid deposition policy debate has focused on long-distance transport, even though local sources are believe to be significant in many cases. The relative role of local versus distant sources varies greatly among different receptor sites and remains a major uncertainty in evaluating the effectiveness of possible control strategies.... [W]e are still unable to reliably predict deposition at specific sites or over-sensitive regions of critical concern. The National Program is examining local as well as distant input to deposition.

Aquatic Environment

Location and Description of Acidified Aquatic Environments

General agreement was expressed describing lakes considered to suffer from acidification, as characterized by the following statement by Jerald T. Schnoor, Director of Environmental Engineering, University of Iowa:

> Approximately 300 lakes which have been sampled are quite acidic, less than a pH of 5. And this is out of a total number of 4,000 lakes sampled, and a total number of maybe 18,000 lakes in the regions where these acidic lakes have been determined.
>
> These lakes lie in sensitive areas of the Adirondack Park in upstate New York, New England, and the Upper Peninsula of Michigan...
>
> These lakes represent only about 0.3 percent of the surface area of lakes in the regions of interest. And most of the acid lakes are in the Adirondack Mountains of New York.

Particular problems in the Adirondack Mountains were characterized in the following statement by Senator Robert C. Byrd:

> A 1980 study by the New York State Department of Environmental Conservation indicated that between 1975 and 1979, surveys had been conducted for 849 of the 2877 lakes and ponds in the Adirondacks. The 849 lakes accounted for 29.5 percent of the total number of lakes, and about 80 percent of the total surface acreage of such waters.
>
> According to the report, 212 lakes were found to be acidified; in other words, with a pH factor of 5 or less. These lakes accounted for 4.7 percent of the surface acreage included in the study.

Others presented additional information on the scope of the problem: Carl Bagge of the National Coal Association (NCA) noted that of 219 acidic lakes, 209 were in the Adirondack State Park; Michael Bergman of the American Public Power Association (APPA) pointed out that other documented areas with acidified surface waters included the La Cloche Mountain region of Ontario, Nova Scotia, southern Norway, and southern Sweden; Administrator Ruckelshaus answered questions to say that although many of the existing 13,000 lakes in the Adirondacks and New England were not sampled yet, an additional few hundred were estimated

to also be acidic; that the average size of 110 acidic lakes in the Adirondacks was approximately 40 acres with a range from 4 to 818 acres; and, that acidified lake size was smaller than the average size (190 acres) of all lakes in the region excluding Lake Champlain. Senator Byrd observed that reports of acidified surface waters in the south eastern U.S. were ambiguous; and that Western cases were the result of localized conditions.

As stated by Administrator Ruckelshaus, emphasis in this hearing was on lakes, with minimal attention to flowing waters where transient acidified conditions have been reported, such as at snowmelt.

Considerable variability in acidity may be observed among aquatic environments in the same vicinity, as suggested by Ralph M. Perhac, Director, Environmental Assessment Department, Electric Power Research Institute:

> We find, for example, that lakes, under similar geologic and rainfall conditions, can have remarkably different acidities, even though they're just a few miles apart. We find, for example, that soils can play a very significant role, if not the major role, in what the acidity of a lake may be. We find, even in sensitive regions like the Adirondacks, some soils can have neutralizing capacities that can last for hundreds, if not even thousands of years.

Sensitive aquatic environments were identified by Dr. Bergman as those vulnerable to acidification due to overlying granitic soils with minimal natural neutralization (buffering) capacity to balance acid deposition. The presence of sensitive aquatic environments was reported in areas beyond those where existing acidified conditions, as was stated by Dr. Schnoor:

> There exists a significant number of sensitive lakes in the United States, in the northeast, upper midwest, southeast, and mountainous regions of our country.

Mr. Haase of the Western Regional Council, emphasized potential vulnerability of high elevation mountain areas in the West while Dr. Bergman stated that generally sensitive regions also included the Smokey and Rocky Mountains, and the northwest and northcentral U.S. The Adirondacks were considered the most sensitive region in the U.S., according to Dr. Perhac. Although, as noted by Administrator Ruckelshaus, the number of lakes protected by high soil buffering capacity cannot be estimated currently, Dr. Bernabo stated that maps have been developed which claim to indicate sensitive areas.

However, Dr. Perhac advised caution in accepting simple assessments of vulnerability:

> We feel that we must exercise great caution in trying to estimate .... the susceptibility of regions to lake [acidification] simply by looking at geologic maps alone, or by looking at maps, say, of water alkalinities. We feel that each watershed has to be studied in itself before we can draw some conclusion as to the susceptibility of that area or of that lake.

Theories on Sources of Enhanced Acidity in Aquatic Environments

Testimony was divided on the causes of acidification of aquatic environments. Some witnesses such as George M. Hidy, Senior Scientist, Environmental Research and Technology, Inc., questioned any strong connection between acid deposition and aquatic environment acidification:

> The NAPAP investigators met and collectively retreated from an earlier position about the causes of apparent damage due to acid deposition. Changes in surface waters and forests have been observed, for example, but the causes are not definitely associated with acid deposition.

Others such as William M. Brown, Hudson Institute, suggested that natural processes could cause the observed acidification:

> Natural sources of acidity exist which could account for most of the relatively few acidified aquatic systems. The principal sources are a) the naturally acidic soil of the forest floor, especially where the underlying rocks are low in alkalinity and b) wetlands (bogs and marshes) which are adjacent to lakes, or through which streams flow on the way to lakes.
>
> Land-use effects such as clear-cut lumbering tend to reduce soil acidity. More important the remaining litter becomes susceptible to forest fires which, if they occur, will leave a strong alkaline ash that could have a beneficial impact on aquatic ecosystems for decades.
>
> Other effects such as the massive growth of the northeastern forests since the 1930s (an estimated 70 percent increase) should lead to increased soil acidity, which in turn could stress the aquatic ecosystems in areas with little alkalinity. Could the effectiveness of the U.S. Forest Service in protecting forests have been indirectly responsible for the loss of fish in some sensitive areas?

However, Administrator Ruckelshaus refuted the theory that natural sources were responsible for the acidification of many clear water lakes:

> Acidification of surface waters has been suggested to be caused by natural soil acidity. .... The surface water would have a brown color, however, as a result of this form of acidification.
>
> Those lakes which have been identified as acidic due to acid deposition do not have a brown color, indicating that the acidification is not from organic acids. These acidified surface waters have high levels of sulfate suggesting that the acidity is from acidic deposition. Also, nitrate has been shown to be related to acidification in these waters, again as a result of acidic deposition.
>
> Therefore, acidification can result, in certain limited cases, from soil organic acids, but acid deposition is thought to be the cause in cases of acidified clear water lakes.

Many witnesses agreed that acid deposition could be directly linked to acidification of aquatic environments, as summarized by Dr. Schnoor:

> Most scientists would agree that these lakes [in the Adirondack Mountains] have been acidified at least in part by acidic deposition for the following reasons:

No. 1. Generally, in sensitive regions where we find significantly acidic precipitation -- I'm defining that as pH less than 4.6 -- we find some acid lakes -- lakes defined as less than pH 5. Where we do not find acid rain, we do not find acid lakes.
2. Sulfate from SOx emissions is a dominant anion in precipitation in these regions, and in the lakes. There exist strong correlations between sulfate in precipitation and sulfate in the lakes, and this is similar to correlations reported for acid lakes in Scandinavia and other locations.
3. Hydrologically, we know that there exists some acid lakes in which 90 percent or more of their water comes from precipitation falling directly on the surface of the lake. The chemistry of these lakes is greatly influenced by the chemistry of precipitation. Land use and forest precipitation are minimal in these cases.
4. We know that lakes do respond to changes in sulfate and acid loading. What's more, the process is not completely irreversible. Lakes near the smelter at Sudbury, Ontario, and the LaCloche mountain lakes, about 70 kilometers south of the smelter, were acidified over a relatively short period, on the order of ten years. Recent measurements on these lakes have indicated a significant decrease in acidity since emissions and acid deposition from the smelter have decreased.
5. Based on research at a few calibrated watersheds in sensitive areas of the Adirondacks, the Hubbard Brook Forest, a watershed in New Hampshire, lakes in the Dorsett area of Ontario, and seepage lakes in northcentral Wisconsin, we know that some 50 to 100 percent of the total acid inputs to these lake watersheds is due to the acidity of precipitation.

Historical Perspective on Acidified Aquatic Environments

As discussed earlier, past and future trends in acidity are uncertain and disputed. Some lakes exhibited natural acidified characteristics long before industrialization occurred, as pointed out by Dr. Perhac:

> EPRI's study has not yet identified lakes in the Adirondacks which have been acid for thousands of years. One of the original three lakes we studied (Woods Lake) apparently has been acidic for well over 100 years. Professor Whitehead (Indiana University),

> under support from the National Science Foundation, studied a number of lakes in the Adirondacks and reported in the literature that some have been acidic (based on diatom paleolimnology) for about the past 8,000 or 10,000 years, i.e., since the end of the last glaciation.

It was even suggested by Mr. Bagge that this might be the cause of much of the currently observed acidified lakes and the American Paper Institute and the National Forest Products Association suggested acidification as a possible long term natural cycle that certain aquatic environments experience.

Some research points to a period of increasing acidity, as suggested by Earle F. Young, Jr., Vice President for Energy and Environment, American Iron and Steel Institute:

> Quantitatively, however, acidity trends in surface waters have been difficult to estimate. In the Northeast, between the 1930s and 1970s, it appears that there may have been a decrease in pH and an increase in acidity in some water bodies, particularly in areas of low buffering capacity.

Concurrence in the 1930s as the point from which recent increases in lake acidification are noticeable was expressed by Dr. Alan Hill, Chairman of the Council on Environmental Quality (CEQ).

Recent investigations concluding that acidification of aquatic environments is currently stabilized or not worsening, and possibly improving were summarized by James M. Friedman of the law firm Guren, Merrit, Feibel, Sogg, and Cohen:

> Recent data collected with comparable testing equipment and procedures demonstrates that the acidity phenomenon appears to be improving, not worsening, in those areas which have been of most concern. In June, 1982, the New York Department of Environmental Conservation released data which indicated that between the periods 1975-1978 and 1980-1981, the number of lakes listed as "critical" (pH below 5.0) decreased significantly and the number of lakes listed as "satisfactory" (pH over 6.0) increased by a very large percentage. This trend has been confirmed in a series of recent reports by the U.S. Geological Survey. The USGS reports demonstrate that sulfate concentrations of surface waters in the Northeast have been improving in recent years.

and by Dr. Perhac:

> We have already been in [the Adirondacks] for five years monitoring regularly, and we can measure no change under present conditions.

Particular notice is taken of reports that sulfate concentrations in New York State streams decreased an average of 1 to 4 percent per year between 1965 and 1978. Mr. Young and others observed that despite the reported decrease in sulfates, pH levels had remained stable or slightly decreased. Administrator Ruckelshaus expressed hope that current EPA investigations of recent acidification rates through lake coring may provide additional information.

The actual importance of the widely mentioned New York sulfate decreases as indicative of the current rates of acidification was questioned in material submitted by Dr. Manowitz of Brookhaven National Laboratory:

> The apparent decrease in sulfate deposition at Hubbard Brook largely results from reference to relatively high values recorded in the initial years (approx. 1965-1969). Since that time, there appears to have been little or no further decrease in sulfate deposition, even though emission inventories over subsequent years did continue to decrease. Meteorological variability could have accounted for this deposition record, even if there had been no change in emissions....

Prognosis for the future was cautiously optimistic, as expressed by Dr. Schnoor:

> In my opinion with regards to that question [whether acidity of lakes is increasing or decreasing], I think that the lakes -- if the acid deposition continues to remain roughly constant, as we believe it is, then the lakes -- what you see is what you get. The present damage can be monitored now, and it's not changing.

Dr. Perhac stated the following:

> ... our mechanistic models indicate that under present acidity conditions, we will not be able to measure any change in the lakes [in the Adirondacks] for at least the next decade or so.

However, according to Administrator Ruckelshaus, two major questions remain in forecasting future acidification trends: how many acidified lakes are at a stable equilibrium with current rates of acid deposition and what are the soil buffering capacities delaying potential response by currently non-acidified surface waters. The National Academy of Sciences had preliminarily concluded that acid deposition at the current rate could not be expected to result in additional damage where watersheds have achieved an equilibrium with acidification processes.

Damage or Other Impacts of Enhanced Acidity in Aquatic Environments

Damage to aquatic environments is generally recognized to accompany acidification. Changes in fish populations are most widely recognized as evidence of larger aquatic ecosystem impacts. However, the extent of such damage is not clear and the relationship of observed damage to theoretical cause (i.e., source of acids) is debated.

Several witnesses were unequivocal in their assessment that observed changes were caused by enhanced aquatic acidity. Administrator Ruckelshaus stated:

> The NAS Panel on Processes of Lake Acidification concluded that "streams and lakes acidified by acid deposition have a different biotic structure than non-acidified streams and lakes."

Dr. Bernabo agreed stating the following:

> In terms of effects of deposition, there's no question that certain lakes have been affected, and fisheries loss has taken place.

Others, while acknowledging that acidified aquatic environments were detrimentally altered, were more hesitant in citing acid deposition as the cause. Dr. Brown stated:

> Many scientists tend to believe that acid rain is responsible for the loss of fish in some lakes and other undesirable aquatic effects in the more sensitive areas; .... However they usually concede that the evidence is circumstantial—that is, other explanations for the observed effects, while not known, cannot be ruled out.

Dr. Bergman stated:

> Loss of fish populations associated with acidification of surface waters has been documented in at least five areas around the globe, including the Adirondack Mountains and parts of Canada. .... However, these statements do not draw a cause and effect relationship. And relating emissions to deposition and then to impacts cannot yet be accurately defined.

and Dr. Hill stated:

> ... present data are sparse and a direct cause and effect relationship between acid precipitation and adverse effects has not been determined.

Still others, recognizing that changes have occurred in acidified environments, question the importance of these changes and our current understanding of what has actually happened. Dr. Hidy stated:

> The effects [of acid deposition] on aquatic and terrestrial ecosystems involve complex chemical interactions with surface waters, soil media and biota. These are poorly understood at present and probably will remain so for sometime to come. The historical effects on surface waters and forests are ambiguous and poorly documented after close examination of available data.

Mr. Haase agreed:

> A small percentage of lakes in the regions of northeastern North America sensitive to acid deposition have been acidified, and their biota have changed. But the extent of actual aquatic damage is not well established.

Mitigation of Acidified Aquatic Environments

Due to the complexity of determining the sources of acidification in aquatic environments, research has suggested mitigation procedures for acidified waters. Dr. Brown presented the following cost estimate:

> To the extent that liming of selected lakes and streams can be shown to be a desirable and cost-effective interim, if not long term, measure for creating a desirable ecological balance that approach should be pursued. A cost-sharing federal-state prototype program might be advisable over the next ten years. It is hardly likely that even a large effort involving 200 lakes would cost as much as $20 million/year in 1983 dollars. [According to EPRI, lake-liming costs should average about $60 per acre. The 178 Adirondack lakes in critical condition have about 7,500 acres. Thus about $4.5 million would be required for each application if all of them were to be limed. Repeat applications may be required every three years or so.]

John Jarvis, National Legislative Representative, United Mine Workers of America, agreed, stating the following:

> However, this [requirement for further research] does not mean that we cannot begin immediately to treat those lakes found to contain high levels of acidity. According to the Environmental Protection Agency, studies have shown that treating the affected lakes with limestone or soda ash can have very beneficial effects on plants and fish life in the affected areas. The cost of such a program has been estimated to be $19 million if all the known acidified and threatened bodies of water were treated.

However, caution was expressed that such mitigation may not be the only answer, as stated by Administrator Ruckelshaus:

> ... at this point we're not suggesting [lake liming] as an exclusive strategy, because we don't know really how widespread this [problem] is.

Also, caution was expressed regarding the overall success of liming as stated by Dr. Schnoor:

> Lake liming can help maintain the pH of a lake high, which could possible improve their chances of a reproductive fishery. But I'm told by my ecologist friends and colleagues that there are other damages, more subtle damages that would occur.

Terrestrial Environment

Soils

Soils link the aquatic and terrestrial environments. As stated in the preceding section on the aquatic environment, acidification vulnerability of the ecosystem is usually related to overlying granitic soils with minimal natural neutralizing capacity.

Managed Soils and Crops. There is general consensus that managed, agricultural soils are not very susceptible to detrimental effects from acid deposition. As Dr. Richard Klein and Hubert Vogelmann of the University of Vermont explain, "[s]uch lands are regularly fertilized and their acidity adjusted." Therefore, other pollutants may have more of an effect on crops than acidic deposition, either directly or through soil-mediated processes. As Dr. Bernabo states:

> Scientists have found little conclusive evidence for major direct effects of acid precipitation on vegetation at current deposition levels. The direct effects on crops appear less significant than those related to other air pollutants such as ozone. . . . Although future research is required to increase the certainty of our conclusions, concern over crop losses has decreased substantially.

Unmanaged Soils. Both positive and negative effects have been observed from the input of sulfur and nitrogen into the soil. The positive effects are exhibited because nitrogen and sulfur, the major components of acidic deposition, are also primary plant nutrients, and sometimes act as a fertilizer.

Negative effects are hotly debated. Dr. Bernabo states that "[f]or unmanaged soils, recent studies on natural soils acidity production have decreased concerns over soil pH changes."

But Dr. Dale Johnson from Oak Ridge Laboratories states that "[i]n terms of soil acidification and plant nutrition, sulfur and nitrogen are in many ways more important than acidity itself..."

There are many unanswered questions involving the effects of acidic deposition on soils. These include the leaching of essential nutrients in the soil, decreased microbial activity, the take up of toxic elements like aluminum through the roots of plants, and the rate of weathering of bedrock materials.

Dr. Dale Johnson attempted to simplify the leaching process and explain the importance of nitrogen and sulfur:

> Many of us find it useful to conceptualize the process of soil leaching (transport of elements via solution) as a function of the inputs, production, and mobility of anion (negatively charged ions such as sulfate, nitrate, and naturally produced bicarbonate). If the anion associated with acid deposition (sulfate or nitrate) is not adsorbed by soils or taken up by forest biota, then acid deposition will cause an immediate increase in the leaching of base cations (such as calcium, potassium, and magnesium) from soils. In extremely, acid soils, readily available base cation reserves are low (by definition) and aluminum may affect plant roots and/or be transported to lakes and streams where it may produce undesirable effects.
>
> The leaching effects referred to above occur immediatly when inputs of sulfate or nitrate add significantly to the natrual levels of anion (mostly bicarbonate and organic anions) in soil solution. These effects will also disappear rapidly if added sulfate and nitrate are removed.

The rate at which soil weathering occurs is crucial to understanding how soils react to acidic deposition. According to Dr. Johnson, the soil weathering rate is the rate at which the soil can regenerate neutralizing base cations. Weathering and its relationship to the leaching process and the possible subsequent soil acidification is also explained by Dr. Johnson:

> There is no doubt that sufficiently high inputs of acid can acidify forest soils. It is not easy to define those "sufficiently high inputs," however, since one of the most crucial processes, soil weathering, cannot be easily quantified. Weathering in this context refers to the replenishment of available, or more precisely, exchangeable base cations from non-exchangeable soil reserves. It is a crucial process because it actually determines the degree to which soils can be acidified by acid deposition. That is, if acid deposition-accelerated leaching exceeds weathering, soils will acidify and if weathering keeps pace with leaching, no acidification will occur.

The relationship between acid deposition, mineral weathering, leaching, and the soil neutralizing capacity are not completely understood. Because of the lack of data, there is disagreement about whether acidification of the environment is occuring from acidic deposition, the rate at which it may be occurring, to what extent lakes and forests are buffered by the watershed soil characteristics, and the subsequent long-term effects of an acidified environment.

Natural Soil Acidification Process. One of the most polarized discussions on effects of acidic deposition is whether soil is acidifying only or primarily through natural processes. The National Acid Precipitation Assessment Program states that a "The deposition of acidic substances on soils may be making only a minor contribution to the natural soil acidification process." But Dr. Bernabo, in response to questions asked at the hearing, states with respect to soils and forests, "Available evidence seems to support combined pollutent effcts on foliage, although soil-mediated processes cannot be ruled out at this time."

Forests

Nature and Extent Forest Decline. Throughout the world, especially in central Europe, forests are showing signs of damage and declining productivity. West Germany exhibits the most dramatic problem. A country-wide survey indicates that 34-percent of the total forest area are showing symptoms of "Waldsterben" -- the name West Germans have given their forest decline phenomenon. Dr. Peter Schutt, Professor of Forest Botany and Pathology at the University of Munich in West Germany, states that "Waldsterben started almost at the same time in different parts of the Europe" and "within four years it was found over large parts of the continent." In the past four years, Dr. Schutt claims that "Waldsterben" has attacked almost every tree species independent of the geologic origin of the soils, climate, terrain, forest management, or structure of the forest.

Dr. Schutt characterizes Waldsterben as a disease complex:

> A collaboration of several single pathogenic events — biotic or abiotic — which attack simultaneously or one after another so that it is difficult to decide which of the causes is primary and which is secondary.

In spite of the difficulties, Dr. Schutt states:

> There are a number of special facts and observations which make the Waldsternben-syndrome a pathological phenomenon standing apart from ordinary tree diseases. Moreover, these facts are to a certain degree difficult to interpret. They lead us to the impression that the syndrome is going to destroy the forest as an ecosystem.

Forest damage and decline has also been observed in the United States, although not to the same degree. Much of the affected forest area is in the East. Dr. Ellis Cowling, head of the National Atmospheric Deposition Program since 1976, describes the situation in the eastern forests:

> A consistent and simultaneous decrease in rate of growth since the early 1960's has been reported in red spruce, shortleaf pine, and pitch pine. Both young and mature stands of red spruce have also shown a progressive dying back from the top, particularly at high elevation. The area of affected spruce forests estends from southeastern Canada to the southern Appalacian mountains. At the summit of Mount Mitchell, reproduction of both red spruce and Frazier fir and all woody shrubs was found to be inhibited above about 6,359 feet in elevation.

There is little debate about whether the current decline of forests in Europe and North America is real; the debate centers around identifying which of many hypotheses correctly explains why the phenomenon is occurring.

Hypotheses for Possible Causes of Forest Decline. Acid precipitation has been found to be a common denominator in many of the damaged forested areas. Dr. Dale Johnson from Oak Ridge Laboratories remarks in the hearing transcript that:

> We have correlated information that some trees die or grow more slowly in areas receiving acid deposition, but no cause effect relationships have been established . . .

Dr. Robert Bruck and Ms. Sandra Meier from North Carolina State University agree, and believe that:

> Some common threads connect the West German and eastern United States observations; the affected forests are located in areas that are receiving large atmospheric inputs of acidic substances and other pollutants. As a result, considerable attention has been given to the possibility that the atmospheric deposition of acids or other air pollutants may be a cause or a contributing factor in observed dieback or decline phenomenon.

This has led many scientists to suspect, along with the Environmental Protection Agency, that not only acid deposition but "that air pollution may be involved in some way" in forest decline.

Therefore, the various hypotheses regarding forest decline involve many different pollutants and biological and chemical mechanisms. As described by Dr. Bernabo:

> These hypotheses involve various pollutants acting alone or in combination, such as sulfur dioxides, nitrogen oxides, trace metals ozone, and acid deposition.

Some of the mechanisms thought to be possible causes include magnesium deficiency, acidification-aluminum toxicity from the soil, heavy metal concentrations, general natural and manmade stresses, and natural acidification of the forest ecosystem.

These hypotheses are based on a variety of symptoms that have been observed either in the field or in the laboratory. These symptoms include, but are not limited to, decreased growth, mortality, loss of nutrients, accelerated erosion of leaf surfaces, foliage tissue injury, leaching of vegetative tissues, increased susceptibility to infection and insect attacks, inhibition of reproduction, decreased incidence of mycrorrhizae (a beneficial) root-inhabiting fungi, and increased uptake of aluminum and other toxic metals.

Consequently, one of the most prevalent theories is that one or more of the various pollutants, or other stress factors, acting alone or in combination with others, are affecting the trees directly or damaging the forest ecosystem. Dr. Ellis Cowling of North Carolina State University relates a popular summary of the situation:

> It is widely assumed (and I think correctly so) that airborne pollutants and/or acid deposition are among the stress factors that have caused or are contributing to the symptoms observed in the forests of eastern North America. But this idea, like those pertaining to central Europe, is still only a hypothesis; it has not been proven unequivocally.

Michael Bergman of the American Public Power Association sums the situation by stating that although

> ... relating deposition to impact cannot yet be predicted... the common threads among the reports of declining forest growth are that the phenomenon is real, it is apparently occurring at an accelerated pace, and many different pollutants and mechanisms are involved at different sites.

Examples of Forest Damage in the United States. Two examples in the United States where forest damage is noted is on Mt. Mitchell in North Carolina and at Camel's Hump, Vermont. Dr. Bruck and Ms. Meier summarize their findings in North Carolina:

> Our observations, which suggest that major climatic perturbation (drought, abnormal high or low temperatures) is not of significance in the southern Appalacian mountains, strengthen the hypothesis that atmospheric deposition may contribute or be causal in the etiology of red spruce decline.

At Camel's Hump, Vermont, drought was suspected as a possible natural cause of forest damage. The research of Dr. Richard Klein and Hubert Vogelmann from the University of Vermont presents information that combines observed symptoms and various pollutants to develop this hypothesis:

> Although North American forests are not receiving the level of acidic depositions seen in Europe, well-studied areas in Vermont and New York are showing the same sequence of events and the same decline syndrome. ... The working hypothesis is that the declines are due largely to the combined actions of acids and solubilized metals... that damage to terrestrial ecosystems is caused by damage or alteration of a number of components that interact in such ecosystems. ... Attempts to derive an alternative hypothesis consistent with all available facts — as does exist for the hypothesis of acid-metal interactions — have not been successful.

As discussed in the sections on the aquatic environment and soils, some scientists believe that the damage that is observed in forests and lakes is from natural causes. Klein and Vogelmann state with respect to natural causes being responsible for the damage at Camel's Hump:

> Hypotheses based on drought, insect, or disease etiology are grossly inadequate, although drought certainly can be a contributing stress factor explaining some but not all of the observed and simulated alterations. Inadequate evidence and illogical interpretations mitigate against acceptance of a drought causation much as this would please some sectors of the economy.

Status of Information. Scientists agree that no direct cause and effect relationship has yet been found for the damage that forests are receiving. As Ralph Perhac, director of the Electric Power Research Institute expressed it:

> We are hard-pressed to relate that damage to a specific agent or to demonstrate effects that can specifically be attributed to acidic deposition.

Dr. Arthur Johnson capsulizes the problems researchers experience in trying to find a cause and effect link:

> We cannot, at present, confidently assess what is actually happening or what might happen in our forests based on the experimental results because we lack detailed process-level information, because the experimental acid applications are not uniform in producing benefit or harm, and because the experimental conditions are simple compared to the complex of factors which controls the growth, reproduction, and health of trees in the forest.

Many scientists think that because causal relationships cannot at present be identified, more research is the most reasonable course of action. The American Paper Institute and the National Forest Products Association state:

> The lack of scientific consensus on possible damage to forests and other ecosystems, coupled with aberrations on what should have been the expected trends in deposition and effects . . . lead the forest products industry to a consensus view of serious reservation about the environmental benefit which would result from several of the acid rain control proposals now before Congress. . . . We strongly support the research program. . . directed at finding answers to questions that should be resolved before any additional plan on acid rain can be developed.

Others, however, think that current research can be used to make more firm decisions. Dr. Klein and Dr. Vogelmann believe that:

> . . . studies of research groups in North America and Europe have amassed a great deal of pertinent information from which reasonable probability predictions can be made.

Dr. Ellis Cowling states that:

> . . . it seems prudent that the United States begin the planning and evaluation procedures now, recognizing that research is continuing and that the earliest possible date for achievement of significant decreases in emissions (except through energy conservation and decreased use of energy and materials) will be the mid-1990's.

Administrator Ruckelshaus cautioned against proceeding too fast, however, as he described the biggest concern for any mitigation action based on forest ecosystem effects:

> Our current knowledge, however, does not tell us whether the offending pollutants are sulfates, nitrates, oxidants, heavy metals, or some combination of these pollutants. This new information, while troubling, raises the possibility that is we act too quickly, we may not control the proper pollutant.

Dr. Arthur Johnson suggests the following in light of the uncertain effects on forests:

> I suggest that any political decisions made with our current level of understanding should take into account that recent trends in growth and mortality are, in many cases unfavorable, that these trends have been identified in areas receiving a mix of pollutants including acid rain, and that the sum of the evidence suggests that airborne pollutants are reasonable possibilities as major contributors.

Other Effects

Two other areas that received brief attention during the hearings were the effects of acid rain on human health and materials. Generally research in these areas has focused on air pollution effects in general, not acid rain specifically. Hence, the relative importance of acid rain to this general air pollution problem is uncertain and disputed. For example, the report of the Connecticut Agricultural Experiment Station submitted for the record concluded the following about acid rain and human health:

> There is little evidence of any direct effect of acid rain--i.e., increased acidity of rainfall--on human health. The notion that acid rain will burn skin or dissolve one's clothing has no basis in fact. However, there is no question that some forms of air pollution are harmful to health. Specifically, fine particulate aerosols can lodge in the lung and cause respiratory problems. A portion of these aerosols are acidic due to the presence of sulfur oxides. The association between these air pollutants and human health is statistical, rather than clinical, with one published study indicating an increase in mortality in New England due to air pollution. The precise role of sulfate aerosols in this complex air pollution problem is not known.

The need for further research into the human health aspects of acid rain was also mentioned by Klein and Vogelmann in a presentation submitted for the record:

> Questions relating to the effects of acidic depositions on public health are currently unanswered, due to inadequate field, epidemiological and laboratory simulation studies. Two aspects of health must be considered. Particulates, particularly covalently bonded sulfate, forms obvious hazes and can be respired. Those at the micron and sub-micron range can enter bronchi and alveoli and serve as irritants. People with respiratory disorders have reported asthma episodes, but epidemiological relationships have rarely been evaluated nor is there firm evidence for or against conversion of these particulates into free acids in the lungs.

Dr. Bernabo summarized the current knowledge of the effect of acid rain on human health as follows:

> The direct effects on human health of inhaling sulfate particles and aerosols continue to be studied under other pre-existing Federal programs. Studies in the National Program of acid deposition's relationship to human health focus on the new area of indirect effects after these substances are deposited. In this context, no signficant indirect human health effects have yet been documented in the United States as being a consequence of the deposition of acid.

The situation regarding materials is similar to that for human health effects. As stated by Klein and Vogelmann:

> The effects of acidic deposition on structures and materials has received considerable attention, although the topic is more complex than has generally been believed. Deterioration is caused by pollutants, heavy vehicular traffic, neglect as well as age, and acidic depositions are only one part of the story. Well-publicized figures on the causes and costs of deterioration are generally guesstimates although there is reasonable assurance that acidic depositions are involved.

In summarizing the work of Yocum (1981), the Connecticut report stated the following:

> Yocum (1981) summarized the types of damage to materials that can be caused by air pollution as shown in Table 1. In testimony to the Task Force, Yocum indicated that acid rain itself has little effect on material damage. Most damage is caused by dry deposition or sorption of gases, particularly SO2 and NOx, which then react with dew or other moisture. Other environmental factors contibuting to damage are sunlight, temperature, freezing and thawing, micro-organisms and salt.

TABLE 1: Air Pollution Damage to Materials

Materials	Type of Damage	Principal Air Pollutants	Other Environmental Factors	Methods of Measurements	Mitigation Measures
Metals	Corrosion, tarnishing	Sulfur oxides and other acid gases	Moisture, air, salt	Weight loss after removal of corrosion products. Reduced physical strength, change in surface conductivity.	Surface plating or coating. Replacement with corrosion resistant material.
Building Stone	Surface erosion, discoloration	Sulfur oxides and other acid gases, particulate matter	Moisture, temperature fluctuations, salt, vibration, microorganisms, CO_2	Surface reflectivity, measurement of dimensions.	Cleaning and sand blasting. Impregnation with resins, replacement.
Paint	Surface erosion, discoloration	Sulfur oxides, hydrogen sulfide, ozone, particulate matter	Moisture, sunlight, microorganisms	Weight loss of painted panels, surface reflectivity.	Repainting, replacement with more resistant paint.
Textiles	Reduced tensile strength, soiling	Sulfur oxides, nitrogen oxides, particulate matter	Moisture, sunlight, physical wear	Reduced tensile strength, reduced fluidity (cotton), surface reflectivity.	Replacement
Textile Dyes	Fading, color change	Nitrogen oxides, ozone	Sunlight	Reflectance and color value measurements.	Replacement
Paper	Embrittlement	Sulfur oxides	Moisture, physical wear	Decreased folding resistance.	Synthetic coatings, storing indoors in pollutant-free atmosphere.
Rubber	Cracking	Ozone	Sunlight, physical wear	Loss in elasticity and strength, measurement of each frequency and depth.	Add antioxidant to formulation. Replace with more resistant materials.
Leather	Weakening, powdered surface	Sulfur oxides	Physical wear	Loss in strength.	Store in indoor pollutant-free environment, replace.
Ceramics	Changed surface appearance	Acid gases, HF	Moisture	Loss in surface reflectivity.	Protective coating, replace with more resistant material.

Source: Yocum, 1981.

Research Programs

Research in the area of acid rain is being funded by both the government and private industry. The backbone of the government's effort is the National Acid Precipitation Assessment Program (NAPAP). Dr. Bernabo, Executive Director of the Interagency Task Force on Acid Precipitation described the goal of the program:

> The goal of the National Acid Precipitation Assessment Program is to develop and progressively improve on an objective and comprehensive information base for use by decisionmakers. In establishing the National Program in late 1980, the Congress recognized both the urgency of the issue and the long-term need for research to address it adequately. The statutory program which includes research, monitoring and assessment activities, was given a 10-year renewable mandate with annual reporting duties. The need to bring together the many important producers and users of acid deposition information was also recognized, with 12 Federal entities united to work together in an integreted effort. This unique long-term and broad-based approach was recognized as esstential in order to tackle effectively the great complexity of the acid precipitation issue.

Recently, the Administration announced a 1985 budget request for increased funding for NAPAP which would be allocated according to table 2 provided by Dr. Bernabo. As indicated, the focus of the research is currently on atmospheric processes, aquatic effects and terrestrial effects. As noted by many during the hearings, understanding atmospheric processes is important to developing a source-receptor relationship between SO2 and NOx emitters and sensitive areas. On terrestial effects, Dr. Bernabo stated in testimony that the concern of the research was increasely more on forest effects with less emphasis on crops effects. In aquatics, the response of watersheds is receiving considerable attention.

Concern was raised in written questions regarding the adequacy of funding for NAPAP. In response to these concerns, Dr. Bernabo responded:

Table 2

NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

President's Budget Request
FY 1985
($ in thousands)

	EPA	USDA CSRS	USDA ARS	USDA FS	NOAA	DOE	DOI PS	DOI GS	DOI FW	DOI BLM	TOTAL	%
A. Natural Sources					855						855	1.5
B. Man-made Sources	1200					750					1950	3.5
C. Atmospheric Processes	10,576				1005	5260					16,841	30.3
D. Deposition Monitoring	4357	248		145	500	977	322	1870		80	8500	15.3
E. Aquatic Effects	8022			210		150	148	445	1525		10,500	18.9
F. Terrestrial Effects	5610	1045	384	1758		120	329	406			9732	17.5
G. Effects on Materials	975						970	150			2095	3.8
H. Control Technologies	600										600	1.1
I. Assessments and Policy Analysis	3025					1400					4425	8.0
Subtotals:		1293	384	2114			1769	2951	1525	80		
TOTALS:	34,365		3791		2360	8657		6325			55,498	
(%)	(61.9)		(6.8)		(4.3)	(15.6)		(11.4)				

Source: Prepared Statement of Dr. Bernabo

> In any area of research where results are unpredictable, it is always desirable to put as much effort into the work as possible. However, even the Deutch panel [Ad Hoc Committee to Review the National Acid Precipitation Assessment Program] advised that about $55 million in FY 1985 (about 100% increase over FY 1984) was as much as the scientific community could effectively spend. In FY 1985, the President's budget request for National Program research is $55.5 million. The Task Force is presently developing its FY 1986 interagency budget proposal, which will be submitted to OMB in September 1984.

Private research is also occurring. One of the more extensive research programs is being conducted by the Electric Power Research Institute (EPRI). As stated by Dr. Perhac of EPRI, the goal of the program is the following:

> The goal of our EPRI program is to assess the contribution of coal burning by the utility industry to any damage that might result from acidic deposition. In order to achieve this goal, we have designed a program to study: (1) the effects of acidic deposition on ecosystems, and (2) the atmospheric physics and chemistry which lead to the deposition of acidic material--emphasis being on the contribution of coal burning by utilities to the atmospheric processes. By combining (1) and (2), we hope to gain considerable insight into the role played by the utility industry in acidic deposition and its effects on the ecosystem.

While the EPRI program is separate from NAPAP, it has similar goals. Dr. Perhac emphasized the coordination of EPRI's program with other efforts, including that of NAPAP:

> Our research (and research planning) at EPRI is not carried out "in a vacuum". We make a concerted and sincere effort to coordinate with other groups doing research on acidic deposition.... Many of the goals of NAPAP and EPRI are similar but, in almost every instance, our (EPRI and NAPAP) specific research programs are complementary rather than duplicative. We may be studying exactly the same thing but our approaches will be quite different. Lake acidification is a good example. The EPRI approach to the issue is principally mechanistic and process oriented. Such an approach gives little information on the extent of acidification throughout the nation. In contrast, part of the federal effort is an extensive survey to answer the question of geographic extent. The two different approaches to the same issue complement each other very well.

Although considerable research is being conducted, most of the scientists who testified felt that science could answer the question: Do we know enough to act? As stated by Dr. Perhac:

> Let me summarize this testimony by saying that I feel that a fairly strong consensus exists in the scientific community that many significant gaps exist in our understanding of the acidic deposition issue. Whether those gaps are great enough to preclude governmental or industry action is not a question that can be answered scientifically. Because our knowledge will almost always be incomplete, science cannot answer the question, "How much knowledge do we need before we act?"...The regulator or legislator, therefore, faces a difficult question. Does he propose a control strategy that will cost the public money but whose effectiveness cannot be judged in solving a problem which is still not well defined? Society will have to decide the answer to that question. Science cannot.

However, as EPA Administrator Ruchelshaus observed, research can answer the question of "whether we have an emergency on our hands, whether we have something that is a much longer-term kind of a phenomenon at which we could pace our response to it consistent with the nature of whatever harm may be occurring." The importance of research was stated directly by Dr. Bernabo in response to questions from the Committee:

> The understanding of mechanisms in the acid rain issue is vital to avoid spending large amounts of money, dislocating industry and workers, etc, without a reasonably firm foundation that the action will produce the desired benefits.

IMPLICATIONS OF PROPOSED CONTROLS

Witnesses concerned with the economic costs and energy policy consequences of proposed reductions in SO2 emissions presented no consensus on the potential costs of such programs or their energy policy consequences. This section summarizes the major issues and analyses presented by witnesses in four categories: (1) compliance costs for meeting a significant reduction in SO2 emissions, (2) energy policy considerations of such a program, (3) economic growths issues raised, and (4) employment issues raised.

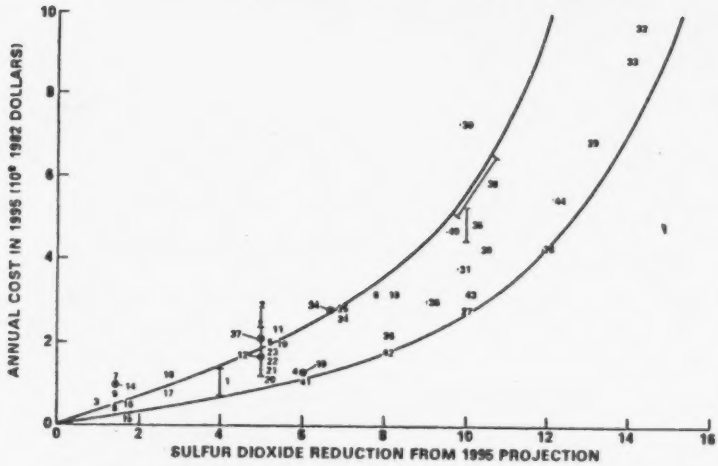
Compliance Costs

Cost estimates presented by witnesses for a 10 million ton reduction in SO2 emissions ranged from $3.5 billion (EPA) to $10.0 billion (Hudson Institute) annually. This range was produced by differences regarding what constituted a control cost, and the assumed strategy used by utilities in meeting the reduction requirement. The uncertainty inherent in predicting compliance actions is illustrated by figure 2, submitted by DOE in response to questions, which plots the results of 44 studies of the costs of various SO2 emission reduction programs. As indicated by the figure, the uncertainty regarding cost tends to increase significantly after about 8 million tons. After 10 million tons, the chart indicates little confidence in cost estimates.

While total costs are uncertain, most witnesses agree that the Midwest would shoulder the greatest percentage of costs, given proposed allocation schemes. Secretary Hodel, in his statement, noted that reducing SO2 emissions would fall on a relatively small number of utility companies (10 companies would shoulder about 45% of the emission reduction burden). This distribution of cost was conceded by Senator Mitchell to be a problem, although he was not fully sympathic to it:

FIGURE 2

ESTIMATES OF 1995 ANNUAL COSTS OF SO_2 ROLLBACK



Source: Department of Energy

> ...the difficulty is that the states that are the hardest hit economically now will be asked to sustain the burden [of reductions], even though their electricity rates are already far, far below those in other parts of the country, and will continue to be far below those in other parts of the country even if my bill were enacted tomorrow and implemented right away.

This contention was vigorously denounced by James M. Friedman of the Ohio law firm of Guren, Merritt, Feibel, Sogg & Cohen. Noting that Cleveland Electric Illuminating Company (CEI) had estimated its 1991-1996 rate impact from acid rain legislation at between 13%-21%, Mr. Friedman stated:

> I place particular emphasis upon the CEI rate ranking because it belies the charge from the Northeast that the Midwest can afford the costs of acid rain controls because the Midwest has cheaper electricity rates than does the Northeast. In fact, CEI's are higher than the rates in all of Connecticut, all of Maine, all of Massachusetts (including Boston) except Nantucket, all of New Hampshire, all of Rhode Island, and all of Vermont. With respect to Northeast Ohio, the "cheap electricity rates" argument is plainly false.

Perhaps the most vigorous debate on compliance costs concerned the most appropriate reduction strategy to be employed if such reductions were deemed necessary. Several witnesses, including Senator Mitchell, the Alliance for Clean Energy (a low-sulfur coal group), the Mining and Reclamation Council, the American Public Power Association, and others, favored a "freedom of choice" reduction strategy that would allow utilities to choose whatever reduction method they wished. Under such a scenario, most analyses indicate that fuel-switching from high to lower sulfur coals would be the first-choice of many utilities, increasing low sulfur coal production at the expense of high sulfur coal production.

Concern about the socio-economic impact of significant fuel-switching has resulted in a different strategy to mandate technological controls and some form of cost-sharing--either through a tax on electricity generated or a tax on sulfur and nitrogen oxides emissions. Many witnesses were openly hostile to cost-sharing; for example, Dr. Haase of the Western Regional Council stated that cost-sharing would "unjustifiably spread the cost (of reductions) to western States where major and costly emission reduction programs have already been implemented and where the potential for a future acid precipitation problem is significantly less than in the East." Secretary Hodel agreed that "polluter pays" was a sound principle; in response to questions by Senator Mike Evans, he said:

> The principle there, in my view, is that it ought to be the user who pays. And if we go into any other — any other system, we find ourselves deciding consciously that we are going to subsidize a particular activity. And we do this all over the lot, I acknowledge, as a society. But I'm saying it would be a sounder approach here to have the particular energy system that produces the pollutant bear the cost of preventing it.

However, given the distribution of costs discussed earlier, Administrator Ruckelshaus acknowledged the practical and political problems of the polluter pays principle in response to a question by Senator Bennett Johnston:

> I guess my sense of it is that as a practical matter if a [n acid rain control] bill of this kind were to stand a chance of passing this year, or in subsequent years, for controlling SO2, there has to be found some way of distributing those costs, or the people in that part of the country that now would bear the full brunt of the cost are going to resist very strongly through their elected representatives in the Congress.

While most of the cost-sharing discussion centered around proposed generation taxes, the American Public Power Association suggested that a sulfur emission tax would provide a more equitible means of cost-sharing.

On the issue of mandating technology, concern was raised by some witnesses regarding the suitability of requiring flue gas desulfurization (scrubbing) in site specific situations, locking utilities into a potentially obsolete technology, and the progress being made toward development of new, more efficient control technologies. In response to written questions from the Committee, DOE identified eight major difficulties with retrofitting scrubbers to existing power plants. They were the following:

1. Available space, both internal to the plant and external (limited land area).
2. Building structure not capable of supporting the additional weight if roof top installation is considered.
3. Existing inducted draft and forced draft fans cannot support the additional pressure drops required by the flue gas desulfurization system.
4. Transportation limitations of both scrubbing reagents and waste products.
5. Availability of additional waste disposal area to handle the large waste volumes generated by flue gas cleaning.
6. Compatibility of existing plant control systems with the added new flue gas cleaning requirements.

7. Loss of salable power which is required to operate the new system.

8. Skills to operate and maintain the new system.

Other economic considerations to retrofitting scrubbers addressed by various witnesses included the remaining useful life of the boiler being retrofitted and the size of that boiler.

While expressly rejecting control programs at this time, John Jarvis, representing the United Mine Workers of America, defended the mandating of technology on both economic and environmental grounds:

> ...the (Clean Air) Act should continue to serve as a tool to encourage and foster the development of new technologies to control air pollution. Technology-based pollution control strategies protect current jobs and provide new ones. One such strategy is embodied in the "percentage reduction" provision of the 1977 Clean Air Act Amendments, which requires all new power plants built in the United States to apply technology to reduce emissions. In this way, traditional regional coal markets and employment are protected. In addition, percentage reduction allows all of our coal resources throughout the nation to be burned in power plants while still meeting the national ambient air quality standards that protect public health. This provision is a good example of public policy that is both economically and environmentally beneficial. It allows us to use our vast coal resources while moving toward energy independence. The concept of "percentage reduction" will save thousands of jobs and will allow our nation's industrial base to continue to use relatively inexpensive local coal while moving toward cleaner air.

Similarly rejecting a control program at this time, Senator Byrd also questioned the economic advantage of fuel-switching, noting that the actual cost-saving to consumers resulting from a freedom of choice strategy over a technologically-mandated strategy depended on the distribution of economic rents between the different participants in the coal supply chain. Depending on that distribution, Senator Byrd indicated that the costs differences to consumers between the two strategies may be small.

Expressing concern about locking polluters into obsolete technology, many questions were directed towards DOE and EPA regarding government programs for developing new technologies and their potential costs. As part of their response to written questions from the Committee, DOE submitted table 3 indicating the status and potential performance of emerging acid rain control technologies. Also, testimony by Leon Green, of the Clean Coal Coalition, advocated the more intensive use of coal cleaning techniques to achieve about 2.5 million tons of SO2 reductions at no net cost.

Energy Considerations

Several witnesses at the hearing identified potential changes in energy usage that might occur due to acid rain legislation. The primary concern expressed by those witnesses was the disincentive to use coal to meet the nation's energy needs. William Marx of the The Council of Industrial Boiler Owners (CIBO) stated that the proposed NOx cap could have a significant impact on coal use:

> This [NOx cap] will exacerbate the bias against coal use, since the higher ratio of NOx emissions over oil or gas (7:3:2) would in effect bar increased industrial coal use and thus cause reconversion away from coal in some plants and stifle new coal projects in others. In some cases it could well lead to plant shutdown.

The Hudson Institute also expressed concern that planned oil to coal conversions would be abandoned, increasing oil consumption by 1 million barrels a day.

Dr. Harry Enoch, Director, Division of Technology, Kentucky State Energy Cabinet; CIBO, and other witnesses also expressed concern that proposed SO2 reduction legislation would result in less incentive to use new emerging technologies to meet emissions reductions. CIBO gave a specific example of this potential problem:

TABLE 3
POTENTIAL PERFORMANCE OF ACID RAIN CONTROL TECHNOLOGIES

TECHNOLOGY	EMISSIONS REDUCTION (%) SOx	NOx	INCREMENTAL COST (MILLS/KWHr)	$/TON SO2	MATURITY
LIMESTONE SCRUBBER	90-95	NEG.	13-20	600-950	AVAILABLE
DRY SCRUBBER	70	NEG.	10-12	780-1080	AVAILABLE
LIMESTONE INJECTED MODIFIED BURNER[1]	30-60	40-50	1-9	215-1390	COMMERCIAL EARLY 90s
ADVANCED SOx/NOx CLEANUP DEVICES	90-95	90-95	6-10	270-610	COMMERCIAL EARLY 90s
CONVENTIONAL PHYSICAL COAL CLEANING	33-50	NEG.	2-5	250-720	AVAILABLE
ADVANCED PHYSICAL COAL CLEANING	55-65	NEG.	4-7	270-450	COMMERCIAL LATE 80s
PHYSICAL AND CHEMICAL COAL CLEANING	80-94	NEG.	13-20	600-950	COMMERCIAL EARLY 90s
PRESSURIZED FLUIDIZED BED COMBUSTION RETROFIT	90-98	75-85	10[2]	420-460	COMMERCIAL MID 90s
ATMOSPHERIC FLUIDIZED BED COMBUSTION RETROFIT	90-95	50-75	12	520-560	COMMERCIAL EARLY 90s

1. EPA FUNDED

2. DOES NOT INCLUDE THE BENEFITS OF LOWER COST ADDITIONAL CAPACITY.

Source: Department of Energy

> a new technology, fluidized bed combustion "which will result in energy conservation and very low air pollution emissions will not be permitted to commence operation because emission offsets are not available in Louisiana." Thus, introduction of this promising solid fuel-burning technique into one of the nation's most energy intensive industries, pulp and paper, is being retarded and could be prevented.

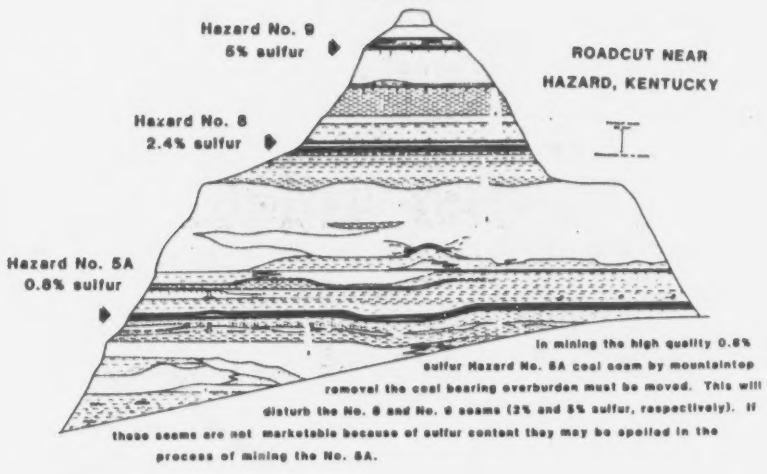
A third concern raised was of reduced reliability and efficiency resulting from power plants forced to reduce emissions. According to Temple, Barker, and Sloan (TBS), an operating scrubber consumes about 5 percent of the power produced by the units. TBS estimated that about 24 billion kwh/year would be necessary to run the scrubbers required under H.R. 3400. TBS also estimated that an additional 24 billion kwh/year would be lost from these units because of reduced reliability.

A fourth concern, raised by Dr. Harry Enoch and illustrated below (figure 3), is that legislation may result in the "high grading" of coal resources. As explained by Dr. Enoch:

> High-grading results when we selectively seek out the highest quality fuels for use today, leaving behind lower quality fuels for tommorrow's users. Another effect of high grading is that lower quality coals may be spoiled in the process of obtaining high quality coal. This occurs to an extent now in eastern Kentucky. If a coal-producer can only sell coals with less than say 1.5% sulfur, he will not save the 3% or 3.5% sulfur coal that may be encountered in mining--it will become refuse. This is poor conservation of our energy resources and it will become worse when coals of 0.5 % to 1% sulfur are being sought. (see Figure 3). This a phenomenon of the marketplace, operators do not mine what they cannot sell. To encourage this by legislation or regulation is to encourage wasting our national energy heritage, and there is a real cost associated with this loss. The cost will be externalized, paid for by future generations, not by the consumers of the power produced today.

Other energy-related concerns mentioned in the statements included decreased total electricity demand, premature retirement of older units, scrubber sludge extraction costs, and potential increased electricity imports from Canada.

FIGURE 3


Hazard No. 9
5% sulfur
ROADCUT NEAR
HAZARD, KENTUCKY
Hazard No. 8
2.4% sulfur
Hazard No. 5A
0.8% sulfur
In mining the high quality 0.8% sulfur Hazard No. 5A coal seam by mountaintop removal the coal bearing overburden must be moved. This will disturb the No. 8 and No. 9 seams (2% and 5% sulfur, respectively). If these seams are not marketable because of sulfur content they may be spoiled in the process of mining the No. 5A.

Source: Prepared Statement of Dr. Harry Enoch.

Economic Growth

Witnesses at the hearing identified both specifics within proposed acid rain legislation and the impact of higher electricity rates resulting from such legislation as potential constraints on economic growth. In particular, John Quarles of the National Environmental Development Association devoted his entire testimony an important potential constraint on economic growth--proposed emissions caps. Seconded in his concern by Carl Bagge of the National Coal Association and other witnesses, Quarles presented a seven point indictment against an emission caps. His points are summarized below:

1. Current proposals fundamentally restructure parts of the Clean Air Act from focusing on the production level at which a plant is designed to operate to one based on the production level at which a plant has actually operated over a specified historic period.

2. An emissions cap can restrict full use of productive capacity if the historial period chosen is one in which the affected plant was operating at partial capacity.

3. An emissions cap will interfere with fuel use as the apparent effect of a cap would be to freeze patterns of fuel use on the basis of 1980 operation. This is critical for industrial concerns which some times quickly shift from natural gas to an alternative fuel due to supply or price.

4. An emissions cap will affect fuel pricing and patterns of use as there will be a heavy demand for low emitting fuels such as natural gas and away from coal and oil.

5. An emissions cap will limit new growth as experience with current offset requirements has been most discouraging.

6. An emissions cap does not integrate well with the Clean Air Act as provisions such as prevention of significant deterioration (PSD), would no longer make sense.

7. The need for an emissions cap is questionable as industrial SO2 may decline in the future without the cap.

Several witnesses from industrial interest expressed concern about the potential costs of acid rain legislation to them--both in direct control costs and in the higher cost of electricity. CIBO expressed the concern that industrial boiler operators would have to pay this double cost for acid rain control on boilers which they did not consider cost-effective to control. The Electricity Consumers Resource Council (ELCON) stated that its analysis of acid rain legislation indicates industrial rate increases on the order of 20 percent.

Illustrative of the industries which would be particularly hard hit by significant increases in electricity rates would be the aluminum industry. Mr. John Bard of the Aluminum Associaton stated that electricity represents one-third of the cost of producing aluminum. As stated by Mr. Bard, foreign smelters already have a large advantage over the U.S. in electricity costs even before acid rain legislation:

> Based on 1982 data, the average U.S. cost of electricity for aluminum production was estimated to be 2.4 cents or 24 mills per kilowatt hour, and in the last year this cost climbed even higher. Our Free World competitors, in contrast, pay an average of 1.7 cents or 17 mills per kilowatt hour. Some foreign smelters including Canadian smelters pay as little as 3 mills. Foreign smelters thus already hold a large competitive advantage in terms of this major component of the cost of producing aluminum.

Roughly 40 percent of the aluminum industry capacity in the U.S. is located in the 31 State acid rain deposition area and is dependent on coal-fired electricity, according to Mr. Bard. Stating that electricity rates could increase by 10 mills per kilowatt hour under acid rain legislation, Mr. Bard observed that significant cost would be added to aluminum smelting. Indeed, Mr. Bard suggested that even the 1-mill fee proposed in H.R. 3400 would damage production, stating:

> In addition, proposals, such as H.R. 5314, which would establish a nationwide acid deposition tax of one mill per kilowatt hour would further damage the competitiveness of many aluminum facilities outside the 31 State region which have been identified as "swing capacity," operating only when aluminum demand is high.

Employment

The potential displacement of high sulfur coal mining jobs resulting from a "least-cost" reduction strategy has been a significant economic issue in the acid rain debate. DOE, in response to committee written questions quoted an ICF study for EPA as estimating 50,000 direct employment losses in high sulfur coal mining areas in 1995 resulting from a "least-cost" reduction strategy. This figure is in the middle of the range of job losses estimated by the United Mine Workers of America which projected 39,000 to 60,000 direct job losses depending on the amount of fuel switching employed. Also, UMWA estimated the indirect job losses from legislation at between

87,000 and 134,000 jobs. These jobs losses are projected to occur primarily in six states: Illinois, Indiana, western Kentucky, Ohio, Pennsylvania, and northern West Virginia.

Mandating technology was projected to reduce the job shift away from the high sulfur coal areas. For example, DOE states in its written responses that the job shift under H.R. 3400 (which mandates some technology) would be only 9,000 jobs instead of 50,000 under the "least-cost" alternative.

While accepting that job shifts would occur, representatives of ACE suggested that the net jobs loss under a least cost reduction plan would be minor due to future coal production and job creation in the low-sulfur coal areas. Stating that to institute a mandatory technology program would cost almost $80,000 a year per job saved, ACE suggested a targeted assistance program to affected miners if there are dislocations.

This analysis was attacked by Dr. Enoch, who stated that the model used to project this result:

> ...is based on several unsupportable assumptions. The most critical of these is that the selection of coal as a future utility and industrial fuel will not be influenced whatsoever by environmental regulations or the cost of environmental controls. THe ICF model predicts a very large (and probably over optimistic) increase in coal use by 1995 and assumes that the same amount of coal will be used regardless of whether or not there is a stringent acid rain control bill.

Also, Senator Byrd, quoting a CRS report, expressed concern that jobs supposely created in eastern low-sulfur coal area would not occur for two reasons. First, there may be more western coal penetration than the small amount assumed by ACE. Second, low-sulfur coal producers may decide to shift production from current low-profit markets to meet demand rather than expanding production and bringing on line new capacity.

PART THREE: RECOMMENDATIONS

Various recommendations of the witnesses and those submitting statements, as well as from materials submitted for the record, have been excerpted and complied in this section. Some recommendations are duplicative, and others are implicit in observations, suggestions, or conclusions of the witnesses. Not every recommendation could be extracted; but every effort has been made to ensure that the compilation fairly represents the range and substance of the witnesses' views. Although the recommendations reproduced in this section are direct quotes, they are excerpted from extended statements and testimony; so readers wishing the full context of any witness' view should consult the hearing record.

The recommendations are compiled by witness, divided into six groups. Since some witnesses' recommendations fall into more than one category, there is some overlap. Any indicated emphasis is in the original.

RECOMMENDATIONS AND POSITION OF ADMINISTRATION WITNESSES

The testimony of the Administration witnesses included two basic points: first, that while acid precipitation is a real problem, knowledge about its causes, effects, and control is as yet insufficient to justify enactment of legislation to control it; and second, that funding should be increased for the National Acid Precipitation Assessment Program authorized by the Acid Precipitation Act of 1980. The Administration has asked for $55 million for fiscal year 1985. In addition, the Administration witnesses stressed that enacting a premature control program--before further research results are clarify the problem--risks misdirected controls (for example, forest decline may be caused by other pollutants) and unnecessary and serious adverse economic and energy impacts.

RECOMMENDATIONS TO ACCELERATE THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, TO LIME LAKES, AND TO RESEARCH CLEAN COAL TECHNOLOGIES

Numerous witnesses voiced support for the Administration's policy. They said that knowledge is still insufficient to justify instituting a control program now, and called for accelerated and increased research. Many of these recommendations specifically called for expanding the NAPAP program.

Also, many of these witnesses supported the liming of lakes to mitigate acidity where possible.

In addition, many of these witnesses supported legislation (e.g., S. 1925) for increasing Federal research, development, and demonstration of new technologies for controlling pollutants and for burning or converting coal to other fuels in non-polluting ways. In the view of these witnesses, such a program offered the opportunity for reducing pollutants associated with acid precipitation more efficiently than immediate control programs could offer, and without disruption of traditional patterns of fuel use.

RECOMMENDATIONS FOR IMMEDIATE ACTION

Some witnesses did feel that the evidence about acid precipitation and its effects justify enactment of a control program. The recommendations for control programs varied in their specificity and detail, but they generally agreed that the program should provide flexibility to ensure cost-effective abatement actions. Perhaps the most important implication of these recommendations lies in their presumption that the acid precipitation problem warrants immediate action and the issue is what form those actions should take.

RECOMMENDATIONS FOR PRINCIPLES TO GOVERN ANY CONTROL PROGRAM, IF ONE IS ADOPTED

Several witnesses who recommended against immediate enactment of acid precipitation control legislation nevertheless stated principles that they thought should govern any control program that might be enacted. Among the principles witnesses recommended were: (1) That the polluter should pay for abatement; in this vein, several witnesses spoke in opposition to cost-sharing proposals. (2) That sources required to abate emissions be allowed the freedom to choose how they would achieve the reductions. (3) That any program balance costs and benefits. (4) That emission caps not be included, because of their potential constraint on economic growth. And (5) that the program not discourage the use of coal resources.

RECOMMENDATIONS FOR RESEARCH

While numerous witnesses referred to one or more research needs in conjunction with related policy recommendations, a few witnesses specified certain research needs. These particularly included the need to study the acid precipitation processes, with the ultimate goal of gaining information that will permit better assessment of how effective controls on emissions might be in abating acid precipitation. While many witnesses pointed out the importance of researching forest decline, there were few detailed research proposals.

MISCELLANEOUS RECOMMENDATIONS.

This group includes recommendations that natural gas use be allowed to count toward pollution reductions; that coal cleaning be encouraged; and that a limited, targetted approach to controls, as once considered by EPA Administrator Ruckelshaus, be reassessed.

RECOMMENDATIONS AND POSITION OF ADMINISTRATION WITNESSES

WILLIAM D. RUCKELSHAUS
ADMINISTRATOR
U.S. ENVIRONMENTAL PROTECTION AGENCY

There is no question that there is an acid rain problem in this country. There is, however, significant uncertainty regarding the scope of this problem, the pace at which damage is occurring, and the specific physical and ecological mechanisms involved.

[There has been much concern about forest decline, but] our current knowledge ... does not tell us whether the offending pollutants are sulfates, nitrates, oxidants, heavy metals or some combination of these pollutants.

This new information, while troubling, raises the possibility that if we act too quickly we may not control the proper pollutant.

This situation illustrates well why waiting for further research to be completed before initiating a control program is a rational environmental decision.

... The way I have attempted to pose the question is whether we have an emergency on our hands, or whether we have something that is a much longer-term kind of a phenomenon at which we could pace our response to it consistent with the nature of whatever is occurring.

The Administration has an active program to respond to the research questions and <u>is</u> in favor of finding a solution to the complex problem of acid rain.

When the fundamental scientific uncertainties have been reduced, this Administration will craft and support an appropriate set of measures to solve the acid rain problem.

DONALD P. HODEL
SECRETARY
DEPARTMENT OF ENERGY

We do not deny that acid rain may be a problem to this country. We think it is being dealt with by the present law, and we do have time, because of the beneficial trendlines, to know more about the problem before we choose the course that we must take to resolve the problem further.

I believe that the 10-12 million tons per year SO2 rollback proposals are of questionable necessity and uncertain benefits. In contrast, I am quite certain that such measures would be expensive, have severe impacts on the energy policy of this country and would move use away from a balanced approach to meeting our energy needs. Unless and until we receive information that would resolve some of these uncertainties in a way that would provide a sound basis for supporting additional measures, I believe accelerated research along the lines of the President's budget request is a scientifically supportable and appropriate course of action for the present.

A. ALAN HILL
CHAIRMAN
COUNCIL ON ENVIRONMENTAL QUALITY

The Administration's Acid Precipitation Program

First, to double the appropriation for the research effort. If the budget request is approved, we will have reached a total investment of more than 125 million dollars since 1982.

Next, a request for a program to help restore the buffering capacity in affected lakes. This program will involve the states in affected areas.

Finally, 67 million dollars has been requested for research and development on new technology in coal combustion.

CHRISTOPHER BERNABO
EXECUTIVE DIRECTOR
INTERAGENCY TASK FORCE ON ACID PRECIPITATION

Information about effects on materials from acid deposition needs to be better defined, including: the extent of materials damage attributable to man-made pollutants, like acid deposition; the rate of degradation; a quantitative evaluation of the processes involved; and a reliable estimate of the materials at risk. Under the National Program, an inventory of materials at risk in the United States is being compiled, and other crucial analyses are underway.

As science advances our understanding of the acid rain issue, data are collected and analyzed, and many different hypotheses are proposed to explain the observed phenomena. Experiments must be designed to test the scientific validity of the various possible explanations. The existence at any one time of several possible explanations can confuse and dismay decisionmakers and the public. But scientific inquiry into complex environmental issues rarely, if ever, can provide simple clear cut answers. The search for understanding is often laborious, while the demands on policymakers are urgent and immediate. The public and decisionmakers understandably become impatient. Yet, only by careful research can a better information basis for decisions be developed.

RECOMMENDATIONS TO ACCELERATE THE NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, TO LIME LAKES, AND TO RESEARCH CLEAN COAL TECHNOLOGIES

WENDELL H. FORD
U.S. SENATOR
KENTUCKY

I strongly support the President's approach of further research before corrective action is taken. I am an original co-sponsor of Senator Byrd's bill, S. 454, which, recognizing that controls on fossil fuel today would be premature, also calls for extensive research and proposes money [for] the mitigation of the effects of acid deposition on lakes and streams, as does the President's.

And I enthusiastically endorse S. 1925, the Coal Technology bill introduced by Senator Byrd that is designed to promote the clean burning of coal, our most abundant natural energy resource.

ROBERT C. BYRD
U.S. SENATOR
WEST VIRGINIA

Before Congress mandates additional sulfur dioxide reductions on the order of 10 to 12 million tons above and beyond the requirements of current law, prudence dictates that the uncertainties about the causes and consequences of acid deposition be addressed as quickly as possible.

I have introduced legislation (S. 454) which would mandate an acceleration of the Task Force efforts and require that the Task Force report to Congress before 1992. My legislaton also provides a program of grants to states to demonstrate mitigation techniques (e.g., lake liming) for sensitive areas affected by acid deposition.

I have also introduced legislation (S. 1925) to establish a five-year program to accelerate the development of new and advanced technologies to allow for the expanded use of all the nation's coal reserves in an environmentally accepted manner.

DAN QUAYLE
U.S. SENATOR
INDIANA

I believe that strategies to control sulfur dioxide emissions as a solution to the acid rain problem, such as those now under discussion in Congress, are premature and cannot guarantee to solve the problem. I believe that President Reagan heeded the voices of wisdom and reason in proposing a program of more research, mitigation, and development of new technology.

In conclusion, I heartily support the President's recommendations as outlined in his State of the Union Address. The President announced efforts to double our research efforts on the science of acid rain. This can only lead to a greater understanding of the nature of the problem to aid policymakers in the development of a more equitable solution. Mitigation efforts in the affected areas will be undertaken while the additional research is being conducted. I strongly support the President's efforts to place emphasis on the development of cleaner and more efficient coal-use technologies. Indeed, this is the key to a solution to the acid rain dilemma.

JOHN WARNER
U.S. SENATOR
VIRGINIA

I have come to the conclusion that there is still not enough "concrete" information available for Congress to approve drastic acid precipitation legislative "cures" like some being currently debated before Congress.

In order to acquire the concrete information I feel is needed, I cosponsored Senator Byrd's bill, S. 454, to strengthen and speed the ongoing acid rain research effort. S. 454 also would provide funding to mitigate the effects of acid rain on affected water bodies and help endangered fish life.

... I cosponsored S. 1925, which would accelerate the development and commercialization of these coal technologies.

Whatever action Congress takes to correct this problem must be based on hard, irrefutable evidence - evidence which is not present today. Moreover, Congressional action must not impair our national security, which includes our energy and economic security, nor should it impose unnecessary costs, burdens and hardships upon the public.

In attempting to resolve the problem of acid precipitation, once all the facts are in, I believe Congress must seek a balanced policy allowing the affected parties maximum flexibility to cure the problem. I believe certain proposed solutions currently before this Congress are not only premature, but also arbitrary and rigid. We do not have adequate information on their effect, and therefore these proposals should be discarded in favor of those proposed by the President, and the distinguished Minority Leader.

HARRY G. ENOCH
DIRECTOR, DIVISION OF TECHNOLOGY
KENTUCKY ENERGY CABINET

We would like to propose the following as an alternative to acid rain control legislation:

First, we ask acceptance of the fact that the acid rain solutions must, of necessity, be long-range, or long-term solutions. The public should not be led to expect a painless, quick-fix to this problem. There simply isn't any.

Saddling one region of the country with major utility emission reductions is not the answer. The solution, ultimately, will require major and expensive reductions of sulfur and nitrogen emissions in all regions of he country.

Secondly, encourage vigorous enforcement of the current Clean Air Act.

And, lastly, create a climate that encourages the development and commercial application of new technology.

And two of the incentives to this end would be the Coal Technology Bill that is before the committee at this time. Another vehicle would be the Synthetic Fuels Corporation.

JOHN T. JARVIS
UNITED MINE WORKERS OF AMERICA

The UMWA believes that the magnitude of job losses described herein is unacceptable, particularly in light of the current lack of scientific consensus on the issue. That is why the UMWA strongly supports legislation, which has been introduced in both the U.S. House of Representatives and the Senate, to accelerate the ongoing study of the causes and effects of acid rain. We must have more data before control legislation is enacted.

EDWARD L. ADDISON
PRESIDENT AND CHIEF EXECUTIVE OFFICER
THE SOUTHERN COMPANY, ON BEHALF OF
EDISON ELECTRIC INSTITUTE

[Our] position is — in these matters of sulfur dioxide emissions -- acid rain — and the condition of lakes and waterways -- we are perfectly willing to follow the scientific facts -- whereever they lead. But first we need the facts.

We espouse a do-the-right-thing policy. And we believe the federal government is doing the right thing by pursuing an accelerated research program under the National Acid Precipitation Act.

CARL BAGGE
NATIONAL COAL ASSOCIATION

The coal industry opposes legislation requiring immediate, massive and costly reductions in SO2 emissions as the means of correcting problems associated with environmental acidity.

We do have time to wait.

We should all be concerned about the acidity of lakes, in the Adirondacks and in Canada, but there's a proper response to this manageable ecological problem.

First, common sense if nothing else dictates that we move as quickly as possible to mitigate the effects of acidity in these lakes.
Where lakes and streams are acidic, we should take immediate action to restore the waters to productive status....

Second, accelerate the existing national commitment to research into the causes and effects of acid deposition.

AMERICAN PAPER INSTITUTE

These findings lead the forest products industry to a consensus view of serious reservations about the environmental benefit which would result from several of the acid rain control proposals now before Congress. Because of these reservations, we strongly support the research program recently outlined by Environmental Protection Agency Administrator William Ruckelshaus before several committees of Congress.

. It is the consensus of the forest products industry that current knowledge is not adequate to support further regulatory action of the magnitude represented by S. 768 and other similar proposals currently before Congress.

JAMES M. FRIEDMAN
FRIEDLANDER, COPLAN & ARONOFF

I recommend that the [National Acid Precipitation Assessment Program] Plan be accelerated and its funding increased, within the bounds of scientific justification, in order that the Plan might provide information useful in the political debate as quickly as possible.

WILLIAM A. BROWN
HUDSON INSTITUTE

Our tentative recommendation to federal policymakers is as follows:

a. Expand the national acid-precipitation research effort over the next 5 years or more, up to $150 million per year, if necessary...

b. Encourage the development of improved cost-effective technologies for reducing the emission of acid precurors and other pollutants from all sources, large and small.

c. To the extent that liming of selected lakes and streams can be shown to be a desirable and cost-effective interim, if not long-term, measure for creating a desirable ecological balance that approach should be pursued. A cost-sharing federal-state prototype program might be advisable over the next ten years.

d. An experimental retrofit program involving $.5 to $1 billion/year for controlling acid-forming emissions from major sources nearest to the sensitive Adirondack area could be the first phase of a potential long-term program of retrofitting—it remains to be proven through research that a Phase-II would be desirable.

e. The last (and still tentative) recommendation is that due consideration be given to a stronger policy of controlling the emission of acid-forming pollutants into the atmosphere from all <u>new</u> fuel-burning installations and vehicles.

Accordingly, our study, which still favors a continuation and strengthening of the Clean Air Act, concluded that from a scientific point of view the proposed acid rain [control] legislation would not be justified.

KAISER ALUMINUM CORPORATION

We believe that the scientific uncertainties surrounding acid desposition indicate that the direction of proposals by the Administration, Senator Byrd, Senator Randolph, Congressman Rahall and others for accelerated study is the most appropriate course of action at this time.

JAMES C. WILSON
PRESIDENT, ROCKY MOUNTAIN ENERGY COMPANY, ON BEHALF OF
ALLIANCE FOR CLEAN ENERGY

[First]... in any new legislation environmental goals should be attained at the least cost. Mandatory use of scrubbers should be avoided, replaced with clear and definite performance standards, allowing those burning coal to elect the least cost method of complying with those standards.

Second, conversion to coal from alternative fuels should be encouraged, again by setting clear, reasonable performance standards for those units.

Third, new technology must be developed quickly to permit the clean burning of high — as well as low — sulfur coal.

Employment displacements within the ordinarily volatile coal industry should be addressed directly by assistance targeted to those whose employment is threatened without massive distortions to the coal market.

E. F. YOUNG
AMERICAN IRON AND STEEL INSTITUTE

We would, therefore, strongly recommend no regulatory program until further research better defines the need for such a program, the benefits to be gained, and the effective means of implementing it.

It is our belief that none of the present [control] proposals provides a national solution, considering all the technical, economic, political and social issues enveloping the acid rain debate. AISI believes that the most appropriate legislation at this time should support an accelerated research program directed at answering the questions raised above, along with modest direct action to mitigate the acidic conditions found in some northeastern lakes.

RECOMMENDATIONS FOR IMMEDIATE ACTION

GEORGE J. MITCHELL
U.S. SENATOR
MAINE

We know enough to act now, and it's our responsiblility to do so.

[The members of the Committee on Environment and Public Works] have weighed all the available evidence and exercised our judgment. We have recommended a legislative approach to address the acid rain problem.

In my legislation, an overall reduction is mandated, but then it is up to each state, working with the utility companies within that state, to identify the most cost-efficient method of achieving a reduction within that state.

But notwithstanding the substantial body of information that now exists, I support wholeheartedly continued acid rain research.

There are gaps in our knowledge. We can, and we should always learn more. But it is time to put aside our differences and focus on our areas of agreement....

The first step towards a solution is to acknowledge that a problem exists. I ask you today to make a balanced judgment, based on the consensus in the scientific community, both in this country and throughout the world, that acid rain is, indeed, a serious problem which warrants a response.

We can then focus on our disagreements as to a solution. I have suggested one solution. Some of you here today have raised strong objections to my legislation.... I welcome your suggestions. I earnestly and sincerely seek a dialogue with any and all members of this Committee and the Senate on how best to accomplish the goal of minimizing acid deposition.

MICHAEL BERGMAN
STAFF SCIENTIST
AMERICAN PUBLIC POWER ASSOCIATION

APPA believes that prudent action to control acid rain is justified now. However, given the large scientific uncertainties and potentially large costs, APPA believes that a cost-effective and flexible strategy must be developed that acknowledges these factors:

- All fossil-fuel combustion and metallic ores smelting are likely to contribute to impacts;
- Both mobile and stationary sources are implicated;
- Though emitted at different levels and rates, and though not equally controllable or equally controllable at tolerable costs, sulfur oxides, nitrogen oxides, trace metals, hydrocarbons, and chlorides are implicated; and
- The potential for adverse impacts is not confined to the Adirondacks or the eastern U.S.

While APPA believes action is warranted now, the actions taken should be moderate in scope.

1. There should be a nationwide funding mechanism based on SO2 and NOx taxes on emissions from all fossil fueled sources.

2. Funds raised should be applied to the most cost-effective emission reduction measures.

3. Emission reductions should be based on a "pay as you go" approach.

4. The reduction program should have two phases, with implementation of the second phase based on an affirmative decision by the Congress.

5. Emission reduction goals should adequately allow for future growth, and emission caps or "offset" requirements should be rejected.

TENNESSEE VALLEY AUTHORITY
STATEMENT OF THE BOARD OF DIRECTORS
BEFORE THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS, FEB. 9, 1984
(INTRODUCED TO THE RECORD BY SENATOR MITCHELL)

... Our position on acid rain is that a reduction in acid precursors is essential in eastern North America, and that Federal legislation is necessary to accomplish this. Reductions should be required of all significant emitters of SO2, both utilities and other industries. These SO2 reductions should be allocated to the States proportionally to their total SO2 emissions for the 1980 base year. States should have flexibility in allocating their required emissions reductions.

The majority of the TVA Board supports legislation now to achieve a 10-12 million-ton reduction in SO2 over the next decade in a cost-effective manner and without subsidies of any kind, but the Chairman prefers to wait until EPA recommends a level of SO2 emissions with the understanding that TVA would meet its fair share of the reductions at that time.

TVA believes in the principle that the polluter should pay ....

From TVA's viewpoint, [Atmospheric Fluidized Bed Combustion] AFBC is an important and viable technology which can significantly benefit the Nation, and it deserves continued Federal support . ..

Other technologies that need further development or demonstration include double alkali using limestone, limestone injection multiple burner; lower cost recovery systems, retrofittable technologies for existing outdated limestone scrubbers, and combined NOx/SO2 removal processes.

Additional research is needed to develop some cost-effective chemical coal cleaning technology that may be tailored to remove almost any desired amount of sulfur from coal, especially for those cases where greater than 50- to 60-percent reduction in sulfur is required.

RICHARD M. KLEIN
HUBERT W. VOGELMANN
BOTANY DEPARTMENT
UNIVERSITY OF VERMONT

It does not seem possible to us that the course and rate of terrestial or aquatic ecosystem deterioration is capable of being slowed, stopped or reversed without very large reductions in the emission of acidic and metal-containing substances. The costs are reasonable and bearable and the public has indicatd its willingness to assume these costs, directly or through taxes. Of course, additional information is required and will, in due course, become available. The major question is, whether more than enough evidence is available now to permit the political and economic sectors to act?

RECOMMENDATIONS FOR PRINCIPLES TO GOVERN ANY CONTROL PROGRAM, IF ONE IS ADOPTED

DALE JOHNSON
ENVIRONMENTAL SCIENCES DIVISION
OAK RIDGE NATIONAL LABORATORY

The verdict as to acid deposition effects on forests must await thorough and objective testing of multiple hypotheses until the important mechanisms causing the damage are found. If these mechanisms are driven by or respond to acid deposition, we can focus our attention on the levels of deposition that can be tolerated. On the other hand, if the damage mechanisms are not affected by acid deposition (e.g., drought, pathogens), we have a separate problem to address.

JOHN N. DALTON
MCGUIRE, WOODS & BATTLE, ON BEHALF OF
UNITED COAL COMPANY

Should your Committee and the full Senate and the House of Representatives determine that legislation is necessary to combat the acid rain problem, I hope that, first, you will conclude that the least-cost alternative freedom of choice mode is preferable, and that secondly, this approach has the support of and will favorably impact on Virginia and our bordering coal producing states.

EDWARD F. HAASE
LAND USE AND RECLAMATION COORDINATOR
PHELPS DODGE CORPORATION

With the knowns and unknowns surrounding the acid precipitation problem and the overall uncertainty as to what course of action will produce beneficial results, prudence might dictate delay.

... We recommend that if any legislation is enacted, it should adhere to the following principles: 1. Move ahead with research to provide the adequate scientific basis upon which to reassess and make long term policy decisions. 2. In the meantime, any reductions should be phased, based upon what we do know, targeted in the East, and with increased mitigation measures as initial reductions are being achieved. 3. Permit flexibility in achieving SO2 reductions and promote use of the most cost-effective methods available. 4. Avoid spreading the cost as it will drive the total cost of reductions up, exacerbate economic effects, penalize those who have already cleaned up, and probably delay the realization of a first phase of reductions by encouraging installation of control technology.

THOMAS ALTMEYER
VICE PRESIDENT, CONGRESSIONAL AND GOVERNMENT AFFAIRS
MINING AND RECLAMATION COUNCIL

Initiation of a massive reduction program at this time is neither justified nor supportable.

Given existing knowledge and projected trends of emissions, we do have time to develop a better information base prior to deciding whether to initiate an additional control program and that we do have time to develop more environmentally efficient emission reduction technologies rather than mandating the extremely costly retrofit of existing sources to achieve reductions for a limited period.

For these reasons, MARC is opposed to legislative proposals which would impose multiyear reductions on sulfur emissions from stationary sources. MARC is specifically opposed to any federally mandated technology or regulatory requirement on existing sources to reduce sulfur dioxide emissions from stationary sources. MARC believes that the private sector, with its inherent competitive forces, is best equipped to determine the most cost efficient and workable compliance technology to meet emission standards established by the Congress.

JOHN C. BARD
ALUMINUM ASSOCIATION, INC.

We find, however, that in the debate on acid deposition, energy, economic and environmental concerns have become intertwined. We urge the Congress to seek an answer that will not penalize major industrial users of electricity such as aluminum ... and will not penalize any one section of the country either environmentally or economically.

JOHN R. QUARLES
CHAIRMAN
NATIONAL ENVIRONMENTAL DEVELOPMENT ASSN./CLEAN AIR ACT PROJECT

The significance of the emissions cap to this committee is that it will substantially affect patterns of fuel use and fuel pricing.

We are greatly worried that an acid rain cap such as contained in S. 768's acid rain provisions in effect placew a cap on production, obstructing the use and expansion of our national industrial capacity.

... NEDA/CAAP strongly recommends that an emissions cap not be part of the proposed acid rain policy.

COUNCIL OF INDUSTRIAL BOILER OWNERS

Legislative concepts could be developed embodying the following principles:

A. Achieve the most equitable cost-effective solution(s) in the shortest time....

B. Insure that national energy and economic goals are not adversely affected....

C. Employ a phased program....

D. Accelerate research in the following fields:

- Integration of results from private sector emission control technology programs already underway.
- Analysis of NOx emissions and their relative contribution
- Development, demonstration and evaluation of SO2 and NOx control technologies.
- Assessment of the relative cost-effectiveness of various SO2 and NOx technologies.

ELECTRICITY CONSUMERS RESOURCE COUNCIL

... We believe that Congress must seriously consider the effectiveness of any proposed legislation in achieving its goals and the cost burden associated with that legislation. We are concerned about the environment but we are also concerned that any program implemented produce sufficient benefits.

LETTER TO THE PRESIDENT
SIGNED BY 24 SENATORS AND CONGRESSMEN
DATED: November 17, 1983

A fundamental principle for dealing with environmental problems is that those who cause a problem should be required to pay for its cleanup.

RECOMMENDATIONS FOR RESEARCH

BERNARD MANOWITZ
CHAIRMAN, DEPARTMENT OF APPLIED SCIENCE
BROOKHAVEN NATIONAL LABORATORY

The National Laboratory Consortium has selected three critical research areas, for which more information is required to produce credible assessments pertaining to acid deposition.

1. Nonlinearity of Acid Precipitation Processes

On what spatial scale is the depostion of acidic, or acidifying, pollutants proportional to the emissions of sulfur and nitrogen species, particularly the oxides?

2. Air-Surface Dry Exchange

What are the area-averaged rates of dry deposition of atmospheric sulfur and nitrogen compounds for realistically diverse landscapes?

3. Watershed Research Studies

The key questions to be addressed by this research are: (1) What are the contributions of the various biological and geochemical processes, and hydrological pathways to the delivery and processing of acidity, alkalinity and aluminum to the aquatic system; and (2) What are the spatial and temporal variations of these processes and pathways through the terrestrial system and receiving waters?

JERALD T. SCHNOOR
CIVIL AND ENVIRONMENTAL ENGINEERING PROGRAM
UNIVERSITY OF IOWA

I suspect that the situation is not going to further deteriorate unless acidic deposition increases. The damage has already occurred.

What is lacking? Trend information.

What should we do? I would propose the following actions based on our present state:

1) Laboratory and field research to fill the gaps, especially in the area of chemical kinetics.

2) The linkage of atmosphere and terrestrial/aquatic models in order to quantitatively answer source/receptor questions of emission controls.

3) A targeted emission reduction program to reduce SOx in a specific region with monitoring and research to determine the costs and benefits.

In summary, there are many good reasons to reduce SOx emissions. The acidification of lakes is not the most compelling reason.

RALPH M. PERHAC
DIRECTOR, ENVIRONMENTAL ASSESSMENT DEPARTMENT
ELECTRIC POWER RESEARCH INSTITUTE

We feel strongly that additional large-scale tracer work is needed in order to resolve the source-receptor relation as quickly as possible.

At EPRI, we still see three major gaps in our knowledge before we are able to improve our knowledge of source-receptor relations. First, we must know the relative contribution of dry deposition to total deposition. Secondly, many questions of atmospheric dynamics need better resolution. Finally, research on cloud processes still has a long way to go.

Let me summarize this testimony by saying that I feel that a fairly strong consensus exists in the scientific community that many significant gaps exist in our understanding of the acidic deposition issue. Whether those gaps are great enought to preclude governmental or industry action is not a question that can be answered scientifically. Because our knowledge will almost always be incomplete, science cannot answer the question, "How much knowledge do we need before we act?"

Despite that massive research effort, I feel confident in saying that we, the scientists, do not yet have the tools (specifically air-quality models) to judge the efficacy of any control strategy that might be promulgated.

IAN BRUCK
SANDRA MEIER
STATEMENT PRESENTED TO THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
FEBRUARY 9, 1984
(INTRODUCED TO THE RECORD BY SENATOR MITCHELL)

Our observations ... strengthen the hypothesis that atmospheric deposition may contribute or be causal in the etiology of red spruce decline. Some of the possible mechanisms that need to be investigated include:

1. Hydrogen ion deposition inducing aluminum leaching, resulting in root toxicity and tree decline.
2. Calcium depletion from the soil matrix causing deficiency.
3. Nitrogen deposition (averaging about 60 pounds per acre per year causing nitrogen toxicity, i.e. death of ectomycorrhizae, uptake of excess N resulting in abnormally succulent crowns and shoots and the resulting thinning of cell walls and the reduction of strengthening tissues decreasing the resistence of red spruce to frost, wind desiccation, and fungal or insect parasites.
4. Effects of the abnormally high concentrations of heavy metals in organic matter and soils on root vigor and hence red spruce decline.

COLORADO RIVER WILDLIFE COUNCIL

We therefore call upon the EPA to establish and administer a western "Acid Rain" clearing house and coordinating responsibility to the end that this important problem will be ultimately handled in the best manner.

EDWARD C. KRUG
ASSISTANT SOIL SCIENTIST
CONNECTICUT AGRICULTURAL EXPERIMENT STATION

... I urge that natural processes of acidification be more carefully considered in assessing benefits expected from proposed reductions in emissions of oxides of sulfur and nitrogen.

MISCELLANEOUS RECOMMENDATIONS

AMERICAN GAS ASSOCIATION

With myriad benefits, select use is a vital alternative for the nation to consider. Now is the time to take advant[illegible] of the environmental benefits of our cleanest burning fossil fuel [natural gas], a long term supply of which appears very attainable. We can do that by: (1) repealing incremental pricing and the Fuel Use Act ban on gas use by powerplants and industry; (2) incorporating in proposed SO2 reduction legislation performance standards rather than specific fuels or control strategies; and (3) directing the Environmental Protection Agency to accept select use as a viable and desirable control technology under existing provisions of the Clean Air Act.

CLEAN COAL COALITION, INC.

The Clean Coal Coalition therefore submits that the question before the Congress should be not how to finance a massive program of parasitic scrubber installations but how to provide appropriate financial incentives for industry to invest in productive facilities for coal cleaning and waste burning which can minimize the need for scrubbing.

The Coalition urges the congress to remove the language in the Clean Air Act stating limits for sulfur dioxide emissions in terms of percentage reductions which effectively mandate post-combustion cleanup only and preclude more attractive, cost-beneficial alternatives.

Comparable changes would also be necessitated in the Internal Revenue Code.

... We would focus Congressional attention on the fact that conventional coal cleaning is, and should be recognized as, the most cost-effective first step toward control of sulfur dioxide emissions which, to some degree yet unquantified, contribute to the formation of acid precipitation.

GEORGE HIDY
SENIOR SCIENTIST
ENVIRONMENTAL RESEARCH AND TECHNOLOGY, INC.

Given these prospects, the proposed legislation for control of SOx emissions seems a bitter pill to swallow with very uncertain benefits for a highly stressed economic system. If progress is to be made, and acid deposition is the malady to be treated, the "Ruckelshaus experiment" appears to be the least painful and perhaps the most instructive of potential benefits for your consideration.